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Proceedings of the Ninth Annual Meeting of the Cotton States Branch American Association of Economic Entomologists

The ninth annual meeting of the Cotton States Branch was held at Memphis, Tenn., on February 1, 1934. The program, scheduled for two days, was completed on the first day of the meeting by dividing it into two sessions and continuing until 7 P.M. It proved to be very interesting and profitable, and was well attended considering the fact that many came at personal expense. Considerable informal discussion followed the presentation of the papers which brought out additional points of interest. The papers dealt with insects attacking crops grown in the southern region.

The meeting was attended by Lee A. Strong, Chief of the U. S. Bureau of Entomology, and Avery S. Hoyt, Acting Chief of the U. S. Bureau of Plant Quarantine, both of whom responded to an invitation for remarks. Mr. Strong discussed the new set-up for the Bureau of Entomology and mentioned policies which will be enforced. Mr. Hoyt discussed certain phases of the work of the Bureau of Plant Quarantine.

On behalf of the parent Association, the Chairman, Dr. Leiby, presented the past-president's diploma to Dr. Hinds, who served the American Association of Economic Entomologists as its president in 1933. In reply to the presentation remarks in which it was hoped that the future held for him many years of usefulness to the profession of economic entomology, Dr. Hinds stated that the diploma would be prized among his most precious possessions and that it was a privilege and opportunity to serve the Association and that he would continue to serve the profession in any line that may be offered to him.

Responding to an invitation to discuss the work of the Association during the past year, Dr. Hinds extended greetings from the new president, Dr. E. F. Phillips, as his official representative, and from the Association as a whole. He stated that there are now 1250 members of

the Association, more than ever before, in spite of economic conditions. Upon application members will be carried on the roll of the Association for 1934 without payment of 1933 dues hoping that better economic conditions prevail. The chief activities of the Association during the year were protests against a discontinuance of federal appropriations for research and extension work in the states and action against a movement to discontinue the Bureau of Entomology and scatter the work of that bureau among other bureaus of the U. S. Department of Agriculture, a step which would have been disastrous to the profession. A special committee headed by Dr. E. F. Phillips did very efficient service in this matter. Dr. Hinds reported on the recent Boston meetings and called especial attention to a committee on publicity to inform the public what is being done in economic entomology. Each member of the Branch was requested to promote safe and sound publicity for the profession as the annual loss from insects in this country totals two and one-half billion dollars and the amount spent for control is only one-fifth of 1 per cent of the loss we are trying to prevent. An investment of two-fifths of 1 per cent of the loss would result in saving many times the amount spent.

PART I. BUSINESS PROCEEDINGS

The meeting was called to order by Chairman R. W. Leiby at 1:30 P.M. on February 1 in the Peabody Hotel at Memphis, Tenn. The following were present:

W. E. Anderson, Baton Rouge, La.
G. M. Bentley, Knoxville, Tenn.
R. P. Colmer, State College, Miss.
N. L. Douglass, Grenada, Miss.
Alfred Fenton, Houston, Texas.
F. A. Fenton, Presidio, Texas.
J. W. Folsom, Tallulah, La.
D. W. Grimes, Durant, Miss.
A. L. Hamner, State College, Miss.
R. W. Harned, Washington, D. C.
W. E. Hinds, Baton Rouge, La.
W. R. Horsfall, Monticello, Ark.
A. S. Hoyt, Washington, D. C.
R. Hutchins, State College, Miss.
Dwight Isely, Fayetteville, Ark.
Edward Jones, Knoxville, Tenn.
R. W. Leiby, Raleigh, N. C.
B. P. Livingston, Montgomery, Ala.
Clay Lyle, State College, Miss.
S. Marcovitch, Knoxville, Tenn.
Paul Millar, Little Rock, Ark.
Jack Milton, Jackson, Miss.
J. C. Moser, Knoxville, Tenn.
J. H. Montgomery, Gainesville, Fla.
J. E. McEvilly, Memphis, Tenn.
R. E. McDonald, San Antonio, Texas.
W. C. O'Kane, Durham, N. H.
N. D. Peets, Brookhaven, Miss.
Josephine Seymour, Tallulah, La.
Oliver I. Snapp, Fort Valley, Ga.
W. W. Stanley, Knoxville, Tenn.
Lee A. Strong, Washington, D. C.
J. E. Wiles, Beebe, Ark.
G. Q. Worthington, Cleveland, Miss.
M. S. Yeomans, Atlanta, Ga.

The report of the Secretary-Treasurer was then read and approved subject to the audit of the auditing committee.

Report of the Treasurer

Balance on hand February 2, 1933		$190.27
Refund from parent Association for expenses for the year ending February 2, 1933		27.23
1931 annual dues from 1 member		1.00
1932 annual dues from 6 members		6.00
1933 annual dues from 11 members		11.00
1934 annual dues from 2 members		2.00
Interest on deposit in Savings Department of First National Bank, Atlanta, Ga		5.56
Paid out:		
Expense for annual meeting in New Orleans (By action of Executive Committee)	$25.00	
Stamped envelopes and stamps	12.27	
Telegrams	3.57	
Printing announcements and programs	5.00	
U. S. tax on 8 checks	0.16	
	$ 46.00	$243.06
Balance on hand February 1, 1934	$197.06	

Report of the Secretary

The number of members in the Cotton States Branch on December 31, 1933, was 219. There was a net decrease of 15 members during the year, after removing the names of those who moved out of the Branch territory or were dropped by the parent Association for non-payment of dues. Although the membership has decreased, it is holding up well in spite of present conditions as there were only 158 names on the roll in 1926 as compared with 219 at the close of last year.

The number of members by states on December 31, 1933, was as follows: Texas 50; Mississippi 34; Florida 27; Louisiana 24; Georgia 20; North Carolina 17; Tennessee 15; South Carolina 10; Alabama 8; Arkansas 8; Oklahoma 6. The following states showed net increases during the year: Florida 2; Arkansas 1; Oklahoma 1. Decreases during the year were as follows: Louisiana 10; Texas 4; Alabama 2; Tennessee 2; South Carolina 1. There were no net changes in the number of members in Georgia, Mississippi and North Carolina. There are several hundred entomological workers in the 11 Cotton States who are not members of the American Association of Economic Entomologists. Members of the Cotton States Branch are requested to urge these men to file application for membership in the parent Association.

The Secretary sent to each member of the Branch an invitation to participate in the regular annual meeting in Memphis, Tenn., on February 1 and 2, 1934. The program for that meeting was mailed to each member on January 22. The proceedings of the New Orleans meeting of the Cotton States Branch were published in the October, 1933 (Vol. 26, No. 5) issue of the Journal of Economic Entomology.

Annual dues in the Cotton States Branch are $1.00. Fifteen of the 219 members have paid dues for 1933 and only three members have paid their 1934 dues which are now payable.

Chairman Leiby announced the committee appointments as follows: Nominations—J. W. Folsom, R. W. Harned and G. M. Bentley. Auditing—Clay Lyle, Dwight Isely and F. A. Fenton. Resolutions—W. E. Hinds, S. Marcovitch and R. P. Colmer. Publications (standing)—Oliver Snapp and Herbert Spencer.

Final Business

Chairman Leiby called for the report of the committees.

The Auditing Committee reported that the books and accounts of the Branch had been carefully auditied, and found to be correct. The committee commended the Secretary-Treasurer for the business-like manner in which the Society's books and accounts are kept. This report was then adopted by motion and vote and a certificate from the committee given to the Secretary-Treasurer.

The following resolutions were duly adopted after reading of the report of the Committee on Resolutions and the Secretary was instructed to send them to the parties concerned:

WHEREAS, The Association of Cotton States Entomologists is enjoying a very satisfactory meeting at Memphis, Tenn., February 1, 1934.

Be It Resolved: (1) That we extend to the members of the Committee on Local Arrangements and to the Managers of the Hotel Peabody our sincere thanks for their efforts in making this gathering so pleasant and profitable.

(2) That we extend to Mr. Lee A. Strong, Chief of the U. S. Bureau of Entomology, our deep appreciation of his presence and of his participation in our session.

(3) That we commend most heartily the policy announced by Mr. Strong of cooperating as closely as possible with State workers in entomology and that we pledge unitedly our fullest support in promoting what seems to be most wise, sound, efficient and economical work in entomological research and insect pest control.

The Nominations Committee presented the following names for officers during the ensuing year: Chairman—S. W. Bilsing, College Station, Texas; Vice Chairman—S. Marcovitch, Knoxville, Tenn.; Secretary-Treasurer (3-year term)—Oliver Snapp, Fort Valley, Ga. These officers were duly elected by motion and vote, and in the absence of the new chairman, the vice chairman, S. Marcovitch, was escorted to the chair by past-chairmen Folsom and Harned where he was duly installed.

By motion and vote the executive committee was authorized to select the place and time for the next annual meeting.

PART II. PAPERS

INSECT SURVEY WORK IN NORTH CAROLINA

By R. W. LEIBY, *State Entomologist, North Carolina Department of Agriculture*

An Insect Survey of one's state, that is the collecting and recording of the insects found therein, would seem to be of obvious importance to all state entomologists, and yet through a variety of causes but few states have attempted this kind of work.

One of the leaders in survey work was the late Dr. John B. Smith, for many years state entomologist of New Jersey, who first published a list of the insects of that state in 1890. He issued a second edition in 1900 which he stated was the most ambitious faunal list ever attempted up to that time in the United States, and a third edition in 1909.

Inspired largely by Dr. Smith's example, Professor Franklin Sherman, when he became state entomologist in September 1900, at once began to collect and record all the insects he came across in North Carolina. All records were entered on a constantly growing card catalog. At first only insect records were kept, but Mr. Sherman's interest in general zoology soon added the vertebrates to the list; while the fact that entomologists have to deal not only with insects proper but with such arachnids as the red spider, and such crustaceans as sowbugs as well as with other groups, gradually added more groups, until now the Division of Entomology of the North Carolina Department of Agriculture tries to keep cards up to date for all forms of animal life. However, since the insects comprise nearly 80 per cent of all animals found in the state, and as this ratio is likely to increase rather than decrease, the catalog is and always will remain predominantly a catalog of insects.

This work has been continued up to the present by Mr. Sherman and his assistants and by the speaker as his successor. By the end of 1919 the survey had grown to such an extent that Mr. C. S. Brimley, who may well be regarded as the South's leading naturalist and who had long cooperated with Prof. Sherman, but not as a member of the Division, was put in charge of the survey. Mr. Brimley devotes nearly all of his time to the survey, in an effort to keep it up to date. His duties include the field collecting of insects, their identification when systematic keys are available, the sending of groups to specialists for identification, preservation of specimens, and recording their distribution and time of occurrence.

The advantages of such a survey are of course very largely scientific but there is a decidedly practical side as well. It is by means of the collection that we can show such as inquire, duplicate specimens of the insects of which they may complain. Only recently a news reporter wanted some information on a "black and blood red bug present on the streets of Greensboro in countless numbers eating up trees and making itself a public nuisance." He recognized the box elder bug as the insect causing a political stir in a usually peaceful city.

Specimens in the collection were of great value during the first years of invasion of the state by the boll weevil, for citizens brought everything from stag beetles to corn weevils. With the collection we were able to show them that the specimens brought were very unlike the boll weevil, or quite like them but not the genuine weevil, in the event that the specimen proved to be an insect such as the chestnut or similar weevil.

The records were of value also at the time of the green clover worm outbreak on soybeans in 1919 when the entire crop was all but destroyed in North Carolina. Instead of it being a new pest as thought by many people, we were able to show a general distribution in the state and previous frequent occurrences of the species, though there was no record of a previous outbreak.

Our records also tell us that Termites have always been common in North Carolina, and the increased damage in recent years is due to faulty construction of dwellings rather than to new hordes of the insects pouring into the state from the southwest.

A more recent practical use of the collection was made on December 11. The showing of thirty-two different species of mosquitoes all of which occurred in the state was particularly impressive to a state conference on that day of public health officers and engineers who were about to inaugurate a state wide malaria and pest mosquito control program.

It is not infrequent that a student in systematic entomology avails himself of the records and studies the species of a group in which he is interested, or finds that a record of the occurrence of one or more species fills a gap in the distribution of certain species. Hence there is good scientific reason as well as economic justification for an insect survey in this or any other state.

It is interesting to note the progress of the survey as judged by the records. Unfortunately we have no exact data on the increase of the number of specimens although these naturally keep pace with the records. Of course, since we make additions to the catalog from pub-

lished records as well as from our own field collecting, it follows that an entry on the cards does not always mean an addition to the collection.

On December 31, 1914, a little more than 14 years after the work had begun there were 4,430 insects on our cards, which number had nearly doubled by the end of 1933. The list now includes 8,704 species of insects. It also includes 1,495 species of other invertebrates and 957 vertebrates. This makes a total of 11,156 species of animals known to date to occur in North Carolina. An appendix to this paper lists the number of species in the various orders. How many more species of insects are we liable to record? This can best be judged by comparison with the New York state list of insects published in 1928 under the editorship of Dr. M. D. Leonard. This list comprises, in addition to the insects, the arachnids and some minor groups, and totals a little over 16,000 species, while our list including the same groups is only a little over half that number. This number, large though it is for New York state cannot be reasonably supposed to include more than two-thirds of the actual number of insects abounding in that state; hence a tentative goal for New York will well be set at a fifty per cent increase, which to be a little liberal, would make New York's insect population total about 25,000 species.

North Carolina in area, and in diversity of climate and topography, compares well with New York and is liable to have quite as many kinds of insects, so that we too may well set our goal at 25,000. However, since we record only 9,100 species at present, quite a distance from our goal. We are hampered mostly, however, not by the scarcity of insects in the state, but by the scarcity of entomologists; since outside this division, the Department of Zoology at State College and one Federal field laboratory, there are no resident entomologists in the state unless there are a few persons with entomological leanings scattered among the different institutions of learning in the state. New York on the other hand has hundreds of students of entomology.

As the Survey progressed publication of some of the results naturally followed, so that in 1903 a list of the dragonflies of the state by Mr. Brimley appeared in Entomological News, followed at intervals up to 1923 by lists of additions in the dragonfly group. Mr. Sherman published lists of the Flat Bugs in 1905, Tiger Beetles in 1904, Scorpionflies in 1908, and Blister Beetles in 1913, and in conjunction with Mr. Brimley, lists of the Horseflies in 1904 and 1908, Butterflies in 1907, and Orthoptera in 1911. Dr. C. L. Metcalf published a list of the Syrphidae in 1916, and Dr. Z. P. Metcalf one upon the Homoptera in 1915. Mr.

Brimley also contributed lists of moths in 1904, 1909, and 1923, of Bombyliidae in 1921, and of Tachinidae and Asilidae in 1922. Mr. Bueno published in conjunction with Mr. Brimley a partial list of the Heteroptera in 1907. Most of the papers were published in Entomological News, and the remainder in the Journal of the Elisha Mitchell Scientific Society.

General progress on the survey was reported by Mr. Sherman in 1904 and 1921 and finally in 1925. In this last paper the total number of insects was reported (March 31, 1925) to be 7,113 and of all other animal forms 2,205. In that same article Mr. Sherman reports the following individuals as being in addition to himself and Mr. Brimley the most important contributors to the good work,—Dr. Z. P. Metcalf, Dr. C. L. Metcalf, Dr. M. R. Smith, Dr. T. B. Mitchell, Mr. J. C. Crawford and the writer.

No attempt will be made here to mention publications by those not now or formerly actively connected with the work, but mention should be made of the splendid work done on the Mayflies of the state by Miss Jay R. Traver, the results of which have been recently published in the Elisha Mitchell Journal.

To show that we have reason to expect the occurrence of as many species of insects in this state as in New York, it may be noted, that with our small proportion of New York State's great company of amateur and professional entomologists, we have made as good progress in some groups as they have. For instance we lead New York in the orders Mallophaga, Orthoptera, Mecoptera, and Ephemerida (due in the last case solely to Miss Traver), and in some of the families of other orders; but as a rule we are from 40 to 60 per cent behind them in the larger groups, due largely to our lack of specialists. Thus in the Hymenoptera we are somewhat ahead of them in the group of wasps and bees, but far behind them in the parasitic groups. Similarly in the Diptera, our list compares well with the New York list in the families of the larger and more easily determined flies, but it is woefully behind in such groups as the Fungus Gnats and Gall Gnats, as alas we have had no Felt or Johannsen to collect, rear and identify them.

Every state in the Union has a rich and interesting insect fauna and while every state may not be either a New York or a North Carolina, yet none is so barren of insect life that it is not worth while to keep records and collect specimens of these small but interesting and important little creatures to satisfy the needs of the present and the curiosity of future generations.

Faunal Statistics of North Carolina

From card catalogue of N. C. Dept. of Agriculture (Division of Entomology)

January 1, 1934

Total number of all kinds of animals 11,136
Total number of all kinds of invertebrates 10,199
Total number of all kinds of insects 8,704

Insects by orders:

1. Coleoptera	2807	13. Plecoptera	41
2. Diptera	1578	14. Corrodentia	30
3. Hymenoptera	1453	15. Mecoptera	26
4. Lepidoptera	1036	16. Siphonaptera	14
5. Homoptera	557	17. Strepsiptera	9
6. Hemiptera	479	18. Collembola	7
7. Orthoptera	214	19. Dermaptera	7
8. Odonata	124	20. Thysanoptera	6
9. Ephemerida	92	21. Thysanura	5
10. Mallophaga	91	22. Anoplura	4
11. Trichoptera	64	23. Isoptera	3
12. Neuroptera	57		

Largest families of insects represented in card catalogue:

1. Carabidae	370	9. Scarabaeidae	216
2. Noctuidae	303	10. Sphecidae	197
3. Chrysomelidae	257	11. Tachinidae	195
4. Curculionidae	256	12. Tipulidae	175
5. Ichneumonidae	235	13. Syrphidae	167
6. Cerambycidae	224	14. Pyralidae	136
7. Staphylinidae	224	15. Miridae	122
8. Cicadellidae	222		

Invertebrates other than insects:		Vertebrates:	
Arachnida	364	Mammals	86
Myriapoda	64	(including 11 marine forms)	
Crustacea	241	Birds	356
Mollusca	378	Reptiles	71
Worms	194	(snakes 42, lizards 7, alligator 1, turtles 21)	
Echinodermata	24	Amphibians	65
Coelenterata	88	(frogs 27, salamanders 38)	
Protozoa	134	Fishes	379
Protochordata	8		
Total	1495	Total vertebrates	957

A PRELIMINARY STUDY OF THRIPS ON SEEDLING COTTON WITH SPECIAL REFERENCE TO THE POPULATION, MIGRATION, AND INJURY

By J. C. GAINES, *Entomologist, Texas Agricultural Experiment Station*

Thrips are usually present in fairly large numbers on seedling cotton and apparently cause considerable injury every year. A high percentage of seedling cotton plants that are malformed and stunted are noticeable in most cotton fields, but it is not always possible to designate the insect that is responsible. The cotton flea hoppers, aphids, and thrips have been known to cause similar injury to cotton seedlings. The work herein reported was conducted in the Brazos river bottoms and upland in the vicinity of College Station, Texas, to determine the population, migration, and injury that is caused by thrips on seedling cotton. *Frankliniella tritici* (Fitch) and *Sericothrips variablis* (Beach) were the two most common species, while *Frankliniella fusca* (Hinds) was observed in small numbers in the two cotton fields under observation.

Fig. 71.—Young cotton plants showing thrips injury.

The population records were obtained at weekly intervals by placing ten cotton plants, collected at random from an upland and bottom land field, in a Berlese funnel and recording the number of thrips as the plants dried out.

The standard tanglefoot screen trap, each wing 3′ x 5′ and facing the four cardinal directions on posts 3′ from the ground, was used to secure the information on migration, but thrips were only recorded from one square foot in the center of each wing.

Infestation records were made on all injurious cotton insects early in the season. Plants that were injured by thrips early before any other insects became abundant were tagged and observed throughout the season. Only plants that showed severe injury were tagged as "thrips-injured", while all the others were classed as normal.

The numbers of thrips and flea hoppers that were found on the cotton in the upland and bottom land fields are shown in Table 1.

TABLE 1. THE POPULATION OF THRIPS AND FLEA HOPPER NYMPHS IN AN UPLAND AND A BOTTOM LAND COTTON FIELD IN THE VICINITY OF COLLEGE STATION, TEXAS

Date	Bottom land field		Upland Field	
	Thrips per 10 plants	Cotton flea hopper nymphs per 10 plants	Thrips per 10 plants	Cotton flea hopper nymphs per 10 plants
April 19..	14	0	6	0
April 26..	19	0	7	0
May 3....	25	0.1	24	0
May 10...	42	0.2	51	0
May 17...	61	0.2	85	0.1
May 24...	392	0.2	371	0.2
May 31...	486	1.5	467	0.4
June 7....	620	1.2	547	0.5

Thrips were found on the two-leafed cotton seedlings on April 19 about the time the cotton was up to a stand. Malformed injured plants were noticeable by May 2 (Fig. 71.) before flea hoppers or aphids established themselves in these fields. Apparently this injury was caused by thrips while the cotton was in the two-leaf stage. The weekly population records were discontinued after June 7, at which time the cotton had attained the height of about 20 inches. These "thrips-injured" cotton seedlings are characterized later by the occurrence of two or more main branches and sometimes by excessive branching of the vegetative branches. (Fig. 72.) This is the type of plant that was tagged the first of May as "thrips-injured" and observed throughout the season for growth, yield, etc.

The curves representing the catch on one trap located in a weed field between cotton fields, and the average catch on three traps located in

three cotton fields are shown in Fig. 73. Thrips were drifting, as indicated by the trap catches, over these fields before cotton was up to a stand. It will be noticed that the peak of catch located in a weed field occurred during the week ending May 3, a week before the peak of catch occurred

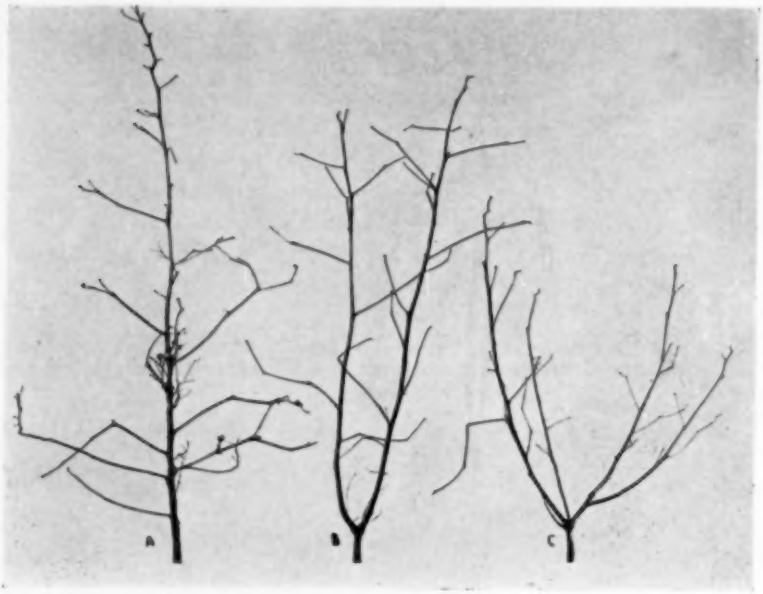

Fig. 72.—(A) Normal cotton plant. (B, C) Cotton plants that were injured by thrips in the seedling stage.

on the traps located in the cotton fields. This indicates that the thrips migrated from the weed fields to the cotton in large numbers at this time, which later caused the population in cotton to increase at a rapid rate.

To secure some information on the effect that thrips injury had on the production of the cotton plants, two points were selected for observation throughout the season. At each point, fifty plants in succession down the row were tagged for weekly square, bloom, and boll records. Thirty-five per cent of these plants were injured by thrips early in the season, the remaining sixty-five per cent being recorded as normal. The normal plants began to set bolls at least two weeks earlier than the injured plants and produced 56 per cent more bolls per plant than did the plants that were injured by thrips. Four individual "thrips-in-

jured" plants that were equally distant from a normal plant and from any other plant in the row produced 36 bolls as compared to 78 bolls that were produced on four normal plants.

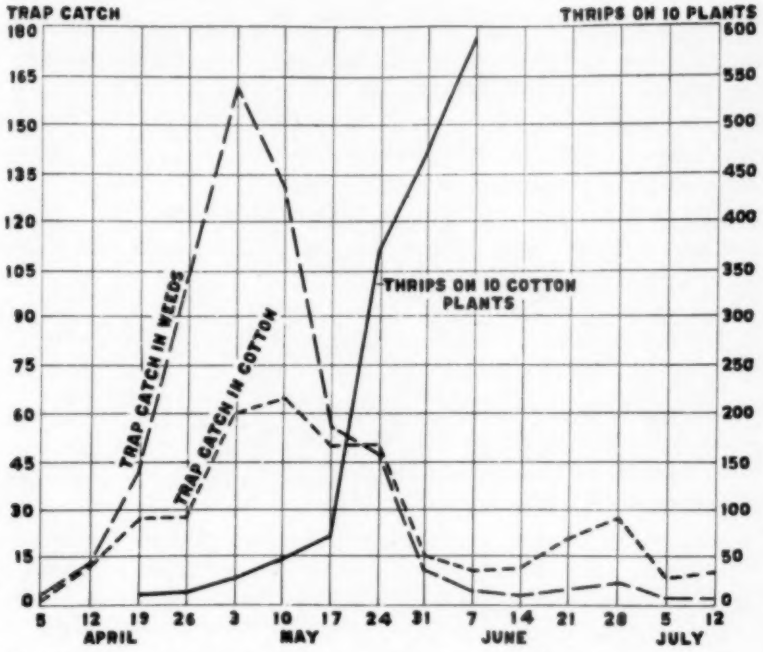

Fig. 73.—Average number of thrips captured per trap in cotton and weeds, and the average number of thrips found on ten cotton plants.

Springtail or Thysanuran Injury. This last spring several of our greenhouse men in Minneapolis growing radishes were very badly bothered with a Thysanuran. The red skin of the radishes could be seen in the alimentary canal through the body wall. As this is the first instance we had seen of this nature we sent some specimens to Dr. F. Silvestri who identified the forms as *Compodea fragilis* Mein.

A. G. RUGGLES

INSECTARY NOTES ON THE FIELD CRICKET

By J. W. FOLSOM, *Division of Cotton Insects, Bureau of Entomology, U. S. Department of Agriculture*

The field cricket (*Gryllus assimilis* Fab., var. *pennsylvanicus* Burm.) feeds on cotton plants every year, and may inflict serious damage to young plants in times of drought.

Our studies of this cricket, which have been carried on for four successive years, at Tallulah, La., are now finished.

The number of generations is two.

The crickets hibernate as nymphs, about half grown.

The adults from these nymphs appear in April and during May. Most of them have died off by June 15.

Adults of the new generation appear about July 15, and thereafter until early in September. Most of these have died off by October 15.

In 1933, males and females were mated in April. Five of these females laid a total of 1,416 eggs from April 19 to June 1, inclusive.

The maximum number of eggs per female was 808.

EGG PERIOD.—Maximum in May, 21 days, with the mean daily temperature 70°F. Minimum in mid-July, 9 days, at 81°F.

MOLTS.—One hundred and thirty-one individuals were carried from egg to adult. The determination of the exact number of molts was difficult at first; in fact, impracticable by direct observation, for (1) molting occurs at all times of day and night; (2) it requires only a few minutes; (3) the cast skin is usually eaten immediately after the molt. So Mr. P. A. Woke, the insectary assistant, devised a method of marking the nymphs in order to ascertain when they molted. This method consisted in placing a minute spot of aluminum paint on the pronotum of each nymph. Then the nymphs were inspected daily, and the inspection could be made rapidly, as the aluminum paint reflected the sunlight like a mirror. The absence of the spot of paint meant, of course, that the nymph had molted since the previous day. Then the nymph was marked again. There was no indication that this process of marking affected the activity or the normal development of the nymph.

In this way the number of molts was determined exactly. It proved to be surprisingly large. Thus 102 nymphs had 10 molts before becoming adults, 14 had 9, 13 had 11, and 2 had 12.

NYMPHAL INSTARS.—There are ten nymphal instars, then, as a rule. These are easily distinguishable from one another by differences in

measurements, coloration, and numbers of hind tibial spines and antennal segments, as shown in Table 1.

TABLE 1. DISTINGUISHING CHARACTERS OF THE NYMPHAL INSTARS OF THE FIELD CRICKET, *Gryllus assimilis* var. *pennsylvanicus*

Instar	Hind tibial spines		Number of antennal segs.
	Outer	Inner	
1	none		34(33–35)
2	2	3	47(46–49)
3	3	3	56(53–59)
4	5	4(5)	71(54–78)
5	6	5	90(79–102)
6	6	5	102(98–113)
7	7(6)	6	140(135–149)
8	7	6	156(148–177)
9	7	6	174(153–196)
10	7	6	188(164–213)

When there are 9, 11, or 12 nymphal instars, these are essentially like the normal 10th instar in their characters. The wing pads appear in the 8th instar, and the ovipositor in the 7th.

In general, the number of nymphal instars is proportionate to the time spent as a nymph. This, in turn, depends on the mean daily temperature. The cooler it is, the longer the period of nymphal development, and the greater the number of molts.

THE DEVELOPMENT OF THE BOLL WEEVIL ON PLANTS OTHER THAN COTTON

By R. C. GAINES, *Entomologist, Bureau of Entomology, U. S. Department of Agriculture, Tallulah, La.*

A progress report on the development of the boll weevil on plants other than cotton was published in the Journal of Economic Entomology in Volume 26, No. 5, October 1933, pp. 940–943. In that paper a summary was presented of the studies during 1932, while this paper summarizes the studies for 1932 and 1933.

Screen-wire cages 18 by 18 by 36 inches were placed over growing althea (*Hibiscus syriacus* L.) plants and cages 4 by 4 by 5 feet were placed over plants of *Hibiscus militaris* Cav., *H. lasiocarpus* Cav., and okra (*H. esculentus* L.) growing in the open field. Reared boll weevils that had not fed on cotton were released or liberated in these cages at irregular intervals. The caged plants and floors of the cages were examined frequently for forms (buds, blooms, and seed pods) that might contain boll weevil eggs. No boll weevils developed in the forms of *Hibiscus militaris*, *H. lasiocarpus*, or okra. Eleven boll weevils

developed in, and emerged from althea buds, from a caged plant. The althea buds in which these weevils developed, and from which they emerged, are shown in Figure 74, numbers 1 to 14. The positive records

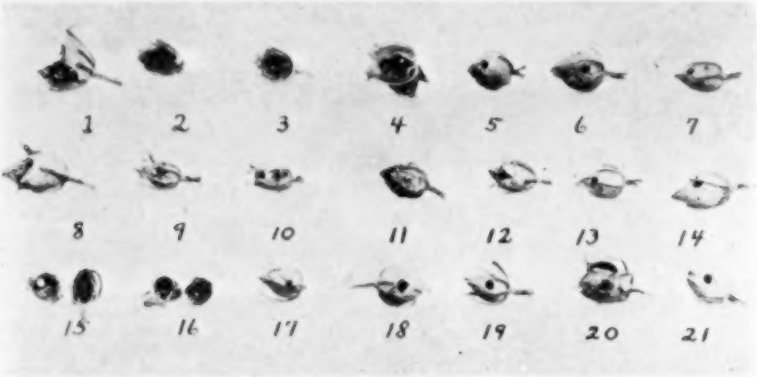

Fig. 74.—Boll weevils developed in, and emerged from, althea buds Nos. 1 to 21 on the following dates: Bud No. 1, female Sept. 12, 1932; No. 2, female Sept. 17, 1932; No. 3, female Sept. 19, 1932; No. 4, female Aug. 16, 1933; Nos. 5, 6 and 7, 1 female and 2 males Aug. 28, 1933; Nos. 8, 9, 10, 11, 12, and 13, 1 male Aug. 31, 1933, 4 males and 1 female Sept. 2, 1933; No. 14, female Sept. 4, 1933 (buds Nos. 1 to 14, inclusive, from caged althea plants); Nos. 15 and 16, male and female Aug. 25, 1933; No. 17, female Aug. 26, 1933; No. 18, female Aug. 26, 1933; No. 19, female Aug. 28, 1933; No. 20, female Aug. 28, 1933; No. 21, male Sept. 23, 1933. (Buds Nos. 15 to 21, inclusive, from althea plants growing in cotton field on Laboratory grounds.)

for the cage tests for both 1932 and 1933 are presented in Table 1. This table gives the numbers of reared boll weevils and the dates on which they were liberated in the cage with the althea plant, the dates on which the shed althea buds were removed from the cage and placed in breeding cages in the insectary for observation, the dates on which boll weevils emerged, and the numbers and sex of the boll weevils that emerged.

In 1933, 16 plants of *Hibiscus militaris*, 18 of *H. lasiocarpus*, 6 of althea, and 18 of okra were grown in a cotton field on the Bureau of Entomology laboratory grounds at Tallulah, La. These plants were located about 10 or 12 feet apart in cotton rows with cotton plants growing between them and in adjoining rows in every case. The purpose was to rear boll weevils on uncaged plants in the cotton field, so that if any egg deposition should take place it would be by free boll weevils which voluntarily selected these plants, since boll weevils were not

TABLE 1. DEVELOPMENT OF BOLL WEEVILS IN THE BUDS OF ALTHEA (*Hibiscus syriacus* L.), TALLULAH, LA., 1932 AND 1933

Reared boll weevils released in cage on althea plant		Date shed althea buds were removed from cage	Date boll weevils emerged	Number of boll weevils that emerged
Date	Number of pairs	1932	1932	
1932				
August 15	10	August 29	September 12	1 female
		29	17	1 female
		29	19	1 female
1933		*1933*	*1933*	
July 11	5	August 3	August 16	1 female
13	5	16	28	2 males
25	5	16	28	1 female
August 2	5	25	31	1 male
16	5	25	September 2	4 males
		25	2	1 female
		25	4	1 female

confined on them at any time. These plants were carefully examined at frequent intervals during the boll weevil breeding season for boll weevils, and for forms (buds, blooms, or seed pods) that might contain boll weevil eggs. Boll weevils were observed at different times in the blooms of althea, *Hibiscus lasiocarpus*, and *H. militaris* but none were observed on okra. One boll weevil was observed feeding on an althea bud. Seven weevils developed in, and emerged from, buds (Figure 74, numbers 15 to 21) collected from 6 althea plants. The dates on which the althea buds were collected from the plants, the dates on which boll weevils emerged from althea buds, and the numbers and the sex of the boll weevils that emerged, are presented in Table 2.

TABLE 2. EMERGENCE OF BOLL WEEVILS FROM ALTHEA BUDS, TALLULAH, LA., 1933

Date althea buds were collected from plants	Date boll weevils emerged	Number of boll weevils that emerged
1933	*1933*	
August 12	August 25	1 male
12	25	1 female
12	26	1 female
12	28	1 female
16	26	1 female
16	28	1 female
September 6	September 23	1 male

Attempts were made in 1933 to rear a second generation of boll weevils on althea. The boll weevils that emerged from the althea buds collected from the cage on August 28 and 31 and September 2 and 4 were placed on an althea plant in a cage 18 by 18 by 36 inches in size. The boll weevils that emerged on August 28 from althea buds collected

from plants in the cotton field were also placed in this cage. The boll weevils that emerged on August 25 and 26 from buds collected from the althea plants growing in the cotton field were placed in breeding cages in the insectary and were fed freshly cut althea buds. The male and female that emerged on August 25 were paired and the two females that emerged on August 26 were paired with males reared from cotton. No boll weevils developed in any of these buds which had been exposed to althea-bred boll weevils.

So far as is known this is the first time that the boll weevil (*Anthonomus grandis* Boh.) has been found breeding in a plant other than cotton and Thurberia (Arizona wild cotton) growing under field conditions. In the previous records of boll weevils breeding in althea buds the plants were grown in cages and no other plants were available. In this case the althea plants were growing uncaged in a cotton field and the weevils were not forced in any way to select althea as a host plant.

Althea is a malvaceous shrub used extensively as an ornamental plant in the States where the boll weevil occurs. The fact that the boll weevil is now known to breed in it must be given consideration in any plan for boll weevil eradication by noncotton zones.

Further studies of host plants of the boll weevil other than cotton are planned for the coming season.

SUMMARY.—Three boll weevils developed in, and emerged from, buds of althea (*Hibiscus syriacus*) from a caged plant in 1932 and 11 boll weevils emerged from althea buds from a caged plant in 1933. In the latter year 7 boll weevils developed in, and emerged from, althea buds that were collected from plants growing in a boll weevil infested cotton field. No boll weevils developed, under either cage or natural conditions, in the forms of *Hibiscus militaris*, *H. lasiocarpus*, or okra (*H. esculentus*). Boll weevils were observed, however, in the blooms of althea, *Hibiscus militaris*, and *H. lasiocarpus*, and one boll weevil was observed feeding on an althea bud. In the cages, boll weevils were observed feeding on the buds, blooms, and seed pods of *Hibiscus militaris*, on the blooms and young seed pods of *H. lasiocarpus*, and on the blooms of okra.

FIELD-PLAT TESTS FOR BOLL WEEVIL CONTROL AT TALLULAH, LA., DURING 1933

By M. T. YOUNG, *Bureau of Entomology, U. S. Department of Agriculture, Tallulah, La.*

For several years prior to 1933 all field-plat tests for boll weevil control conducted by the entomological field laboratory at Tallulah, La., for comparing calcium arsenate with other insecticides had consisted of three plats each. One plat was dusted with the insecticide being tested, one was dusted with calcium arsenate, and the third left untreated as a check plat. In this way each material tested in the field plats was compared with the standard calcium arsenate treatment and with an untreated check plat.

In 1933, in order to make as many tests as possible with a reduced personnel, it was decided to reduce the number of plats treated with calcium arsenate and of the untreated check plats. Instead of 3 plats to a test from 4 to 7 plats, depending on the size of the area with uniform conditions, were used in each test. Eight tests were conducted, these consisting of 3 four-plat tests, 3 five-plat tests, 1 six-plat test, and 1 seven-plat test.

EXPERIMENTAL METHODS. *Arrangement of plats.*—The plats of each test were arranged in series and were parallel to one another. The number of rows used in each plat depended upon the size of the field suitable for the test, and ranged from 18 to 24. The length of each plat, with the buffer area on each end included, was 300 feet or more, depending on the total length of the rows in the field, which was sometimes approximately 500 feet. All of each cotton field selected was planted with the same variety of cotton on the same date, and was apparently uniform with respect to soil fertility, plant growth, stand, and weevil infestation. The aim was to select fields that could be divided into a given number of plats, the potential production of which would be equal were it not for the different treatments given. All plats of a given test received the same kind of cultivation throughout the season, and where fertilizer was used, the same quantity per acre was applied.

Poison applications.—All poison applications on the plats selected for treatment, with the exception of those on the three cultivator-dusted plats in Will Sevier Cut A, were begun as soon as a boll weevil infestation of 10 per cent of the squares was reached and were continued at 4-day intervals, in so far as weather conditions permitted. In all tests, except on Will Sevier Cut A, all the treated plats of each test were dusted on the same dates and at approximately the same time of day. The

cultivator duster used on Will Sevier Cut A was a riding cultivator on which a hand gun was mounted, this being driven by a sprocket and chain from the cultivator wheels. This cultivated and dusted one row at a time. In this test all five plats were cultivated with this machine, but only plats 1, 3, and 5 were dusted with it whenever cultivated, and most of these dust applications were made when the cotton plants were dry. All the remaining treated plats were dusted with hand guns in the early morning when the cotton plants were wet with dew and the atmosphere was calm. These applications were begun at daybreak and were usually completed by 7:30 a.m. Whenever a heavy rain occurred within 24 hours after an application was made, this application was regarded as of no value, and another was made as soon as possible.

Two factories, designated A and B, prepared a supply of both wet-mixed and dry-mixed dusts of 25 per cent paris green and 75 per cent calcium arsenate. In the so-called wet mixtures the paris green and calcium arsenate were mixed while in a wet state and later dried. In the dry mixtures the materials were mixed as dry powders.

Square-infestation records.—Infestation records were begun as soon as the cotton plants averaged 4 or 5 squares large enough to be punctured by weevils, and were continued at weekly intervals until the average number of squares per plant was less than 4 or 5. Each record was made by examining 200 squares in the center and 200 near each end of each plat, making a total of 600 squares examined in each plat. The number of squares examined and the number of punctured squares found at each of the three points were recorded and the average percentage of square infestation was then calculated for each plat. All squares on each plant large enough for this purpose were examined.

Yield records.—Before picking was begun each plat in each test was carefully surveyed and an area was selected for the picking records. In each plat five or more rows on each side were eliminated and 25 or more feet at each end was left as a buffer area. In the untreated plats this method allowed the discarding of the cotton rows nearest the treated plats, which received some benefit from the drift of the dust applications made on the treated plats, and in the treated plats it was thus possible to eliminate some of the plants damaged by boll weevils migrating from adjacent untreated areas. In most plats this method left an area of approximately one-fourth acre on which two or three pickings were made. From the area and the quantity of seed cotton picked from each plat the yields per acre were computed.

RESULTS. *Poison application data.*—Table 1 gives the materials used in the dust applications on the treated plats, the total number of

TABLE 1. POISON APPLICATIONS IN FIELD PLATS IN BOLL WEEVIL CONTROL TESTS, TALLULAH, LA., 1933

TABLE 1. POISON APPLICATIONS IN FIELD PLATS IN BOLL WEEVIL CONTROL TESTS, TALLULAH, LA., 1933

Cut	Plat No.	Insecticide used	Period of treatment	Total number of applications	Number of effective applications	Average quantity of dust used per acre per application
						Pounds
Lane A	1	Sodium fluoaluminate	July 14–Aug. 11	8	7	5.96
	2	Sodium fluosilicate (8 to 12 lbs. per acre)	July 14–Aug. 11	8	7	8.71
	3	Sodium fluosilicate (4 to 6 lbs. per acre)	July 14–Aug. 11	8	7	4.69
	5	Calcium arsenate	July 14–Aug. 11	8	7	5.30
	6	Barium fluosilicate	July 14–Aug. 11	8	7	5.41
Lane B	1	Dry-mixed ca. ars. 75%, Paris green 25%, Brand A	July 14–Aug. 17	9	8	4.90
	2	Dry-mixed ca. ars. 75%, Paris green 25%, Brand B	July 14–Aug. 17	9	8	6.00
	3	Calcium arsenate, Brand B	July 14–Aug. 17	9	8	5.33
	5	Calcium arsenate, Brand A	July 14–Aug. 17	9	8	5.41
	6	Wet-mixed ca. ars. 75%, Paris green 25%, Brand A	July 14–Aug. 17	9	8	5.18
	7	Wet-mixed ca. ars. 75%, Paris green 25%, Brand B	July 14–Aug. 17	9	8	5.52
Evergreen A	1	Dry-mixed ca. ars. 75%, Paris green 25%, Brand B	June 28–Aug. 9	10	9	7.34
	2	Wet-mixed ca. ars. 75%, Paris green 25%, Brand B	June 28–Aug. 9	10	9	6.23
	4	Calcium arsenate, Brand B	June 28–Aug. 9	10	9	7.26
Islington A	1	Wet-mixed ca. ars. 75%, Paris green 25%, Brand A	July 3–Aug. 16	10	9	5.70
	2	Dry-mixed ca. ars. 75%, Paris green 25%, Brand A	July 3–Aug. 16	10	9	5.52
	4	Calcium arsenate, Brand A	July 3–Aug. 16	10	9	5.99
Evergreen B	1	Calcium arsenate	July 8–Aug. 16	11	6	7.31
	2	1 part hydrated lime, 1 part ca. ars	July 8–Aug. 16	11	6	6.91
	4	2 parts hydrated lime, 1 part ca. ars	July 8–Aug. 16	11	6	7.39
Evergreen C	1	Ca. ars. 80%, copper arsenite 20%, Brand A	July 13–Aug. 16	10	5	5.99
	2	Ca. ars. 75%, copper arsenite 25%, Brand A	July 13–Aug. 16	10	5	5.90
	4	Calcium arsenate, Brand A	July 13–Aug. 16	10	5	8.14
	5	Dry-mixed ca. ars. 75%, Paris green 25%, Brand A	July 13–Aug. 16	10	5	7.24
Montrose A	1	Wet-mixed ca. ars. 75%, Paris green 25%, Brand A	July 6–Aug. 25	11	8	6.20
	2	Calcium arsenate, Brand A	July 6–Aug. 25	11	8	6.91
	4	Ca. ars. 75%, copper arsenite 25%, Brand A	July 6–Aug. 25	11	8	5.94
	5	Ca. ars. 80%, copper arsenite 20%, Brand A	July 6–Aug. 25	11	8	5.99
Will Sevier A	1	Cultivator duster—ca. ars	June 16–July 12	5	4	5.11
	2	Standard method—ca. ars	July 15–Aug. 16	8	4	5.58
	3	Cultivator duster—ca. ars	June 16–July 12	5	4	5.07
	5	Cultivator duster—ca. ars	June 16–July 12	4	4	5.05

TABLE 2. SQUARE INFESTATION ON FIELD PLATS IN BOLL WEEVIL CONTROL TESTS, TALLULAH, LA., 1933

Cut	Plat No.	Treatment	Percentage of squares found punctured at weekly intervals*							
			June 19–25	June 26 July 2	July 3–9	July 10–16	July 17–23	July 24–30	July 31 Aug. 6	Aug. 7–13
Lane A	1	Sodium fluoaluminate	6.3	4.3	6.2	19.3	23.5	41.2		
	2	Sodium fluosilicate (8 to 12 lbs. per acre)	7.8	5.3	4.8	28.8	18.5	35.2		
	3	Sodium fluosilicate (4 to 6 lbs. per acre)	3.8	4.0	5.7	22.2	23.8	43.2		
	4	Untreated	11.0	4.8	5.5	17.7	26.0	54.0		
	5	Calcium arsenate	6.3	2.7	7.0	19.3	17.2	34.0		
	6	Barium fluosilicate	2.3	5.8	4.0	18.5	22.7	45.8		
Lane B	1	Dry-mixed ca. ars. 75%, Paris green 25%, Brand A	1.8	2.5	2.8	10.5	7.3	2.7	47.2	26.5
	2	Dry-mixed ca. ars. 75%, Paris green 25%, Brand B	1.5	3.2	5.0	13.8	9.7	7.0	30.3	21.5
	3	Ca. ars., Brand B	3.3	.3	1.3	9.5	8.5	12.0	45.8	26.7
	4	Untreated	3.0	3.8	2.2	14.7	15.5	26.2	69.7	52.2
	5	Ca. ars., Brand A	6.5	5.8	1.3	13.2	7.0	8.0	46.7	25.8
	6	Wet-mixed ca. ars. 75%, Paris green 25%, Brand A	1.2	1.7	2.2	15.3	6.8	8.0	31.3	25.3
	7	Wet-mixed ca. ars. 75%, Paris green 25%, Brand B	3.2	4.3	2.8	8.0	4.5	10.2	19.5	14.7
Evergreen A	1	Dry-mixed ca. ars. 75%, Paris green 25%, Brand B	11.8	9.8	10.8	8.8	10.0	27.3		
	2	Wet-mixed ca. ars. 75%, Paris green 25%, Brand B	8.7	13.8	16.7	3.0	9.0	39.2		
	3	Untreated	12.2	14.7	21.7	31.5	53.7	70.2		
	4	Ca. ars., Brand B	11.8	15.3	11.0	9.0	16.5	47.3		
Islington A	1	Wet-mixed ca. ars. 75%, Paris green 25%, Brand A	14.0	16.0	11.2	9.7	8.3	52.5		
	2	Dry-mixed ca. ars. 75%, Paris green 25%, Brand A	7.0	7.8	10.3	8.0	8.3	55.0		
	3	Untreated	12.0	8.2	10.2	15.2	27.3	71.8		
	4	Ca. ars., Brand A	11.2	8.8	15.0	8.3	9.3	61.3		
Evergreen B	1	Calcium arsenate		13.3	15.7	6.3	9.2	14.7	21.7	
	2	1 part hydrated lime, 1 part ca. ars		9.7	9.0	6.0	8.0	17.2	25.8	
	3	Untreated		7.2	10.5	15.7	23.7	31.0	63.8	
	4	2 parts hydrated lime, 1 part ca. ars		5.0	9.5	4.5	12 0	12.2	18.3	

Evergreen C	1	Ca. ars. 80%, copper arsenite 20%, Brand A		12.0	9.2	18.5	23.0	9.7	22.3
	2	Ca. ars. 75%, copper arsenite 25%, Brand A		8.3	8.0	27.8	20.2	9.0	31.7
	3	Untreated		10.8	7.2	24.8	33.8	41.8	71.7
	4	Ca. ars., Brand A		7.2	4.3	31.5	24.7	9.8	35.0
	5	Dry-mixed ca. ars. 75%, Paris green 25%, Brand A		7.8	3.8	26.2	22.8	8.5	34.2
Montrose A	1	Wet-mixed ca. ars. 75%, Paris green 25%, Brand A		22.8	17.0	6.8	3.0	51.2	24.7	10.7
	2	Ca. ars., Brand A		20.3	14.3	5.2	2.2	55.5	31.3	12.8
	3	Untreated		19.5	13.0	14.3	10.3	51.3	42.3	41.3
	4	Ca. ars. 75%, copper arsenite 25%, Brand A		20.3	14.8	7.0	3.3	45.5	37.8	15.2
	5	Ca. ars. 80%, copper arsenite 20%, Brand A		26.8	19.5	4.2	5.0	50.0	26.0	14.7
Will Sevier A	1	Cultivator duster—ca. ars	5.7	1.8	5.7	4.4	10.3	38.5	
	2	Standard method—ca. ars	9.5	3.2	3.2	7.9	10.3	21.3	
	3	Cultivator duster—ca. ars	8.2	2.7	5.3	6.5	18.7	33.5	
	4	Untreated	8.8	3.0	6.0	9.9	25.5	45.7	
	5	Cultivator duster—ca. ars	5.8	1.2	8.0	5.8	15.3	44.0	

*The successive examinations in each cut were made as nearly as possible on the same day of each 7-day period.

applications, and the number of effective applications on each plat. Those applications washed off by rain within 24 hours were not considered as effective.

Infestation data.—The average percentages of square infestation for each plat of these tests, as determined at weekly intervals, are given in Table 2.

Cotton yields.—The production of seed cotton per acre for each plat, and the increase or decrease in yield for the treated plats, in pounds and percentages, are given in Table 3.

The square-infestation records show that sodium fluosilicate, sodium fluoaluminate, and barium fluosilicate were not so effective as calcium arsenate when applied at the same rate per acre.

When sodium fluosilicate was applied at the rate of 8 to 12 pounds per acre per application it was more effective in controlling the percentage of square infestation than when applied at the rate of 4 to 6 pounds. With 7 effective applications at these rates per acre the plats yielded 8.2 per cent and 17 per cent less seed cotton than the untreated check, while the calcium arsenate plat gave an increased yield of 36 per cent over the check. Light to serious burning of the cotton foliage was caused by most of the applications of sodium fluosilicate. The sodium fluoaluminate plat yielded 1.4 percent less and the barium fluosilicate plat yielded 3.9 per cent more than the check as compared with a 36 per cent increase in yield on the calcium arsenate plat in the same test.

The wet-mixed and dry-mixed dusts of calcium arsenate and paris green of both brands A and B were equally or more effective in controlling the weevil infestation than the calcium arsenate, and in some cases the yields were greater than those on plats treated with calcium arsenate. The comparative yields in the plats treated with the wet-mixed and dry-mixed dusts indicate that there is little difference in their effectiveness. Burning of the cotton foliage was produced by many of the applications of both types of mixtures of brands A and B.

The two mixtures of copper arsenite and calcium arsenate tested gave results about equal to those of the mixtures of paris green and calcium arsenate.

The hydrated lime and calcium arsenate mixture gave very good weevil control, based on the square infestation records, but the yields were not so great as on the plat treated with calcium arsenate alone.

Although there was considerable variation in the increased yields of the three cultivator-dusted plats, the results when averaged are rather promising.

TABLE 3. COTTON YIELDS ON FIELD PLATS IN BOLL WEEVIL CONTROL TESTS TALLULAH, LA., 1933

Cut	Plat No.	Treatment	Yield of seed cotton per acre	Increase in yield of seed cotton per acre	
			Pounds	*Pounds*	*Per cent*
	1	Sodium fluoaluminate	781	11*	1.4*
	2	Sodium fluosilicate (8 to 12 lbs. per acre)	727	65*	8.2*
	3	Sodium fluosilicate (4 to 6 lbs. per acre)	657	135*	17.0*
	4	Untreated	792	—	—
	5	Calcium arsenate	1,077	285	36.0
	6	Barium fluosilicate	823	31	3.9
Lane B	1	Dry-mixed ca. ars. 75%, Paris green 25%, Brand A	1,208	362	42.8
	2	Dry-mixed ca. ars. 75%, Paris green 25%, Brand B	1,321	475	56.1
	3	Calcium arsenate, Brand B	1,263	417	49.3
	4	Untreated	846	—	—
	5	Calcium arsenate, Brand A	1,463	617	72.9
	6	Wet-mixed ca. ars. 75%, Paris green 25%, Brand A	1,516	670	79.2
	7	Wet-mixed ca. ars. 75%, Paris green 25%, Brand B	1,429	583	68.9
Evergreen A	1	Dry-mixed ca. ars. 75%, Paris green 25%, Brand B	1,876	596	46.6
	2	Wet-mixed ca. ars. 75%, Paris green 25%, Brand B	1,767	487	38.0
	3	Untreated	1,280	—	—
	4	Calcium arsenate, Brand B	1,685	405	31.6
Islington A	1	Wet-mixed ca. ars. 75%, Paris green 25%, Brand A	1,479	461	45.3
	2	Dry-mixed ca. ars. 75%, Paris green 25%, Brand A	1,554	536	52.7
	3	Untreated	1,018	—	—
	4	Calcium arsenate, Brand A	1,550	532	52.3
Evergreen B	1	Calcium arsenate	1,307	496	61.2
	2	1 part hydrated lime, 1 part ca. ars.	1,197	386	47.6
	3	Untreated	811	—	—
	4	2 parts hydrated lime, 1 part ca. ars.	1,031	220	27.1
Evergreen C	1	Ca. ars. 80%, copper arsenite 20%, Brand A	1,992	1,056	112.8
	2	Ca. ars. 75%, copper arsenite 25%, Brand A	1,581	645	68.9
	3	Untreated	936	—	—
	4	Calcium arsenate, Brand A	1,468	532	56.8
	5	Dry-mixed ca. ars. 75%, Paris green 25%, Brand A	1,288	352	37.6
Montrose A	1	Wet-mixed ca. ars. 75%, Paris green 25%, Brand A	891	237	36.2
	2	Calcium arsenate, Brand A	841	187	28.6
	3	Untreated	654	—	—
	4	Ca. ars. 75%, copper arsenite 25%, Brand A	904	250	38.2
	5	Ca. ars. 80%, copper arsenite 20%, Brand A	827	173	26.5
Will Sevier A	1	Cultivator duster—ca. ars.	1,270	258	25.5
	2	Standard method—ca. ars.	1,312	300	29.6
	3	Cultivator duster—ca. ars.	1,181	169	16.7
	4	Untreated	1,012	—	—
	5	Cultivator duster—ca. ars.	1,047	35	3.5

*Decrease.

The nine plats treated with the standard calcium arsenate by the standard method gave an average increase of 419 pounds of seed cotton per acre or 45.4 per cent average increase over the untreated check plats. These gains ranged from 187 pounds to 617 pounds of seed cotton per acre, or from 28.6 percent to 72 per cent over the respective check plats.

INSECTS AND A MITE OF POTENTIAL ECONOMIC IMPORTANCE FOUND ON WILD COTTON IN FLORIDA

By C. F. RAINWATER, *Junior Entomologist, Division of Cotton Insects, Bureau of Entomology, U. S. Department of Agriculture*[1]

The wild cotton on which the following insects and a mite were observed and collected belongs to one or two species of *Gossypium* closely related to *G. hirsutum*, from which the upland varieties of cotton commonly cultivated throughout the southern part of the United States have been developed. In the southern part of Florida where these observations were made, however, the plant is a perennial and under favorable conditions grows to the size of a small tree. Measurements were made of plants having trunks with circumferences of 26 inches close to ground level and heights of more than 20 feet. The fruiting season of this wild cotton as determined by observations over a period of 9 months from August 1932 to May 1933 extends from early in October to late in April. The distribution of this wild cotton is confined chiefly to the lower peninsula, the numerous keys, and small islands adjacent to the peninsula off both the east and the west coasts of Florida. Its occurrence on the mainland, so far as recorded, is limited to the coast line, chiefly along the banks of rivers, creeks, and canals, usually a short distance back from where these empty into the bays, or into the Gulf proper on the west side of the peninsula; and around the rims of lakes in the extreme southern part of the peninsula. The most abundant growth observed was on Cape Sable, where large areas occurred on an open marl prairie and back in the hammocks surrounding the prairie. It was also scattered throughout the greater part of the hammock land on the upper mainland keys, and sparsely scattered over the lower mainland keys. On many of the outlying islands and keys there is no high land, but where there is high land, and where vegetation

[1]The fine cooperation of Bureau of Plant Quarantine inspectors who were engaged in pink bollworm work in Florida was greatly appreciated, especially in connection with determining the distribution of cotton and of the insects here discussed.

other than mangrove (*Rhizophora mangle*) occurs, wild cotton is likely to be present. This was found to be true on the greater number of the outlying islands and keys from Boca Grande Key, which is southwest of Key West, and up the west coast as far as St. Petersburg. Only a few of the outlying islands and keys on the east coast, from Key West to Miami, have wild cotton on them, and only one small colony was found north of Miami on the east coast, this being almost directly across Indian River from the small town of Grant, a few miles south of Melbourne. The areas in which the perennial cotton grows is below the frost line.

THE WILD COTTON BORER (*Rhodoneura terminalis* WALKER)[2].—The first record of the occurrence of this insect in the United States was made on March 24, 1932, by Carl Heinrich, who determined as *Meskea subapicula* Dyar, a single female specimen taken by Herman J. Erb on Ulyssa Island, Fla. He later decided this species to be a synonym of *Rhodoneura terminalis* Walker.[2] Its economic status was not established at that time. In May 1932, U. C. Loftin, of the Bureau of Entomology, collected specimens of larvae from the bolls of wild cotton in southern Florida. Although determinations could not be made from the larvae at that time, the potential economic status of this insect was established. After I had reared adults and submitted a series of both larvae and adults to Mr. Heinrich, he determined the specimens collected both by Mr. Loftin and myself as *Rhodoneura terminalis*. This insect was first described by Walker from Santo Domingo in 1865 and has been reported on cotton in Mexico, Costa Rica, Canal Zone, Haiti, Salvador, and Santo Domingo.

Nature and extent of damage.—The larvae of this insect attack and severely damage the stems, squares, blooms, and bolls of the wild cotton by boring into and eating away the inner contents of these parts. When bolls are present the larvae show a decided tendency to attack them. In the absence of bolls, when squares and blooms are present, they attack these parts. Only in the total absence of fruit do the larvae severely attack stems. They enter the tips of the stems and tunnel downward, eating away all but the outer bark as they proceed. They usually tunnel through the stems for a distance of from 2 to 5 inches, depending on the size of the stem, before they emerge to pupate. The attack of the larvae upon squares, blooms, and bolls is almost always at or near the base of these parts, where the pedicel is attached. Outward indication of attack on a boll can rarely be seen, even though the

[2]Order Lepidoptera, family Pyralidae.

entire inner contents may be eaten out, because the point of entrance is hidden by the bracts. When the larvae are ready to pupate they leave the fruiting parts by boring through them, usually near the base where they entered. Under laboratory conditions where infested squares, blooms, and bolls were placed in cages on moist sand, pupation took place within them, but when infested stems were placed in cages, the larvae left all the stems but one, and pupated just beneath the surface of the soil in cocoons made of sand or trash. Under field conditions pupae were never observed in the stems or the fruit; therefore, it may be safely concluded that in the field the larvae leave the infested parts and pupate in the soil.

No extensive life-history work was carried on, but observations of 17 specimens, under laboratory conditions at Miami, Fla., showed that the length of the pupal stage ranged from 7 to 18 days, the average being 12 days. From 81 observations made in the laboratory to determine the length of time required for adults to emerge from infested fruit, it was found that the first adult emerged in 12 days, and that the period of emergence extended up to 32 days. The insects in the material placed in the cages were probably in all stages of development. Therefore, it is probable that the shortest time represented included only the time of development of the pupae, whereas the longest may have included the entire period of development from egg to adult.

Distribution and degree of infestation.—Rhodoneura terminalis has been found in practically every place in Florida where wild cotton grows. The writer has 80 records of its occurrence in separate and distinct locations. Briefly, it may be said to occur on the greater portion of the mainland keys, and keys and islands adjacent to these; on the entire Cape Sable district; along river, creek, and canal banks from Cape Sable all the way along the Gulf side nearly to Tampa; on only the few of the Ten Thousand Islands that have high lands; and on practically all of the islands and keys off the mainland, from near the mouth of the Estero River nearly to St. Petersburg. The degree of infestation in various locations was found by actual count to range from almost nothing to 62 percent of the fruit, and from only an occasional infested stem to almost 100 per cent of the stems.

THE FLOWER-BUD MAGGOT (*Contarinia gossypii* FELT)[3].—The flower-bud maggot was found by the writer on September 17, 1932, and was identified by C. T. Greene of the Bureau of Entomology on June 2, 1933. Apparently this is the first record of its occurrence in continental United

[3]Order Diptera, family Cecidomyiidae.

States. The only references available are from the West Indies, including the Virgin Islands. Wolcott (*4, p. 286*) quotes Ballou as follows: "The flower-bud maggot first made its appearance in Antigua at the end of 1907, where it caused very serious losses in the cotton crop at that time." Wilson (*3, p.* 17) reported, "the flower-bud maggot occasionally attacks cotton flower buds in St. Croix. Its presence may be noted by the flaring of the bracts of the flower buds. This worm causes the squares to drop, resulting in a small crop."

The reports of Ballou and Wilson indicate that the attack of the larvae of this insect is made upon the blooms of the cotton plant. A much different situation was observed on the wild cotton in Florida, for, although the attack was made upon the blooms, it was also made upon squares and bolls. It is more noticeable in blooms, however, because just at the time when the blooms should open normally their bracts flare back, and their petals close inwardly from their tips, giving a sort of rosetted appearance quite similar to that produced by attacks of the pink bollworm. At this stage the inner parts of the blooms are in a state of partial decay and have a characteristic odor. The odor is very noticeable when decay is well advanced. The blooms soon dry up, become brittle, and fall to the ground.

The injury to the squares is similar to that of the blooms and the damage is easily recognized. The squares lose their green color, become yellow, and the base of the squares near the bracts has a tendency to crinkle and become detached from the remaining parts, producing a somewhat corrugated appearance. The inside of the attacked squares appears to be in a state of decay, and the characteristic odor present in severely attacked blooms is also noticeable in severely attacked squares. The injured parts of both squares and blooms are dark in color and contain a great deal of water.

I have seen no reference to attack by the larvae of this insect upon bolls. During the latter part of the fruiting season of the wild cotton in Florida, however, after the squares and blooms on the plants had become scarce, I very frequently observed large numbers of larvae of *C. gossypii* in bolls. In some instances a hundred or more larvae were found in a single boll. The nature of the injury is such that in my notes I have frequently referred to the larvae as "seed-boring larvae." From examinations of infested bolls, it appears that the adult female deposits her eggs on the inside of the boll by piercing it with her ovipositor. The outer part of the boll, where the attack apparently is made, looks shriveled and darker than the remaining part, with numerous tiny punctures in the shriveled places. Immediately after hatching, the larvae appar-

ently bore through to the seed, where they seem to prefer to feed. The lint surrounding the infested seed becomes discolored and practically decomposes, the bolls become soft and watery, and the seeds finally shrivel up. Sometimes the bolls drop to the ground without opening at all. Frequently the boll partly opens but when it does the seeds appear very dry and hard, and have very little lint surrounding them, the lint being weak and easily detached.

A characteristic of these larvae is their habit of springing into the air. They draw themselves into a hump, bringing the posterior end of the body close to the head, and as they straighten out again they spring into the air to a height of 4 or 5 inches and cover a longitudinal distance of as much as 10 inches.

It may, I think, be safely said that the flower-bud maggot occurs wherever wild cotton grows in Florida. Although it was not noted in every specific location, perhaps because of the absence of fruit on the plants at the time observations were made, it was found in every general location, including the small, isolated colony of cotton on the east coast near Melbourne, more than 150 miles north of the nearest known colony on that coast.

A hymenopterous parasite determined by C. F. W. Muesebeck as an undescribed species of *Zatropis* was reared in fairly large numbers from squares, blooms, and bolls infested by this maggot.

THE WEST INDIAN BLISTER MITE (*Eriophyes gossypii* BANKS)—.[4] This cotton pest was not known to occur in the United States prior to June 1932, when U. C. Loftin collected it from wild cotton on Key Largo, and from dooryard plantings of Sea Island cotton in Key West. Outside of the United States it is known to occur in Martinique, Nevis, Barbados, Puerto Rico, and the Virgin Islands.

This mite attacks any part of the cotton plant that is above ground, although its attack upon the fruiting parts is confined to the bracts. It causes wartlike protuberances, and plants attacked are considerably dwarfed, or may be entirely killed. Young seedlings appear to suffer most. The attacks, however, were found to be sporadic. For instance, in one colony of wild cotton a few plants were severely attacked, while other plants within a few yards of these were not injured at all.

The distribution of the West Indian blister mite, in the United States, has been determined as being on Key Largo and Key West, south of the peninsula of Florida; on scattered colonies of wild cotton along river and creek banks on the west coast; and on a few islands off the west coast of Florida, from near the town of Everglades nearly to Punta Gorda.

[4]Order Acarina, family Eriophyidae. Determined by H. E. Ewing.

A COTTON LEAF MINER (*Nepticula gossypii* FORBES AND LEONARD).[5] —This insect was described by Forbes and Leonard (*1, p. 151*) from Puerto Rico in 1930 and I have been unable to find any record of its occurrence elsewhere. It was first found by me in Florida on January 26, 1933, on Angelfish Key, which is slightly to the east of the extreme tip of the peninsula. I later found it on Key Largo, Cape Sable, and numerous keys, islands, and river and creek banks in the general vicinity of Fort Myers. When I first found it, the plants were succulent with new growth, and almost 100 per cent of the leaves were infested. The larvae make sharply angulated mines in the leaves, causing them to fall, and they also mine the bracts of the squares, blooms, and bolls. An infestation such as I have just described causes severe shedding of the foliage.

A single specimen of a hymenopterous parasite, *Closterocerus cinctipennis* Ashm., determined by C. F. W. Muesebeck, was reared from wild cotton leaves infested with this leaf miner, and is thought to be parasitic on it.

Anomis impasta GUENÉE[6].—This insect was described from Cayenne, French Guiana, and has been reported as being found on cotton from Brazil, Barbados, and Cuba. I first reared it from wild cotton blooms from Long Key, Fla., on October 25, 1932. It had not been reported from the United States previously. Its importance as an economic insect seems negligible, but the fact that it has been found on cotton in countries other than the United States and the fact that it is new to this country warrant its being considered as an insect of potential importance.

The above named five species have been discussed in the order of their importance as found on wild cotton in Florida. The first four are certainly worthy of serious consideration on the part of State and Federal entomologists who are concerned with the control of cotton insects.

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[5]Order Lepidoptera, family Nepticulidae. Determined by August Busck.
[6]Order Lepidoptera, family Noctuidae. Determined by F. H. Benjamin.

RELATIONSHIP BETWEEN EARLY VARIETIES OF COTTON AND BOLL WEEVIL INJURY*

By DWIGHT ISELY, *University of Arkansas*

Early production of cotton and the use of early fruiting, rapidly maturing varieties have been recommended for years as a means of reducing boll weevil injury. This recommendation seems to be justified in Arkansas since the yield of cotton produced to the acre by early maturing varieties is usually greater than that produced by late varieties. However, there have been no data to show what part of this apparent advantage of earliness is due to boll weevil injury and what part to other factors; to what extent this difference between early and later varieties could be removed by weevil control; and what degree of earliness is desirable as a means of avoiding weevil damage.

A degree of advantage of the relatively early varieties over later ones in Arkansas is frequently shown by variety tests carried on by the Agronomy Department. That a large part of this advantage is due to weevil activity is suggested by a comparison of yields during years of heavy and of light weevil injury. As for instance a comparison may be made from the published record[1] of cotton variety experiments for 1923, a year of widespread weevil injury, and for 1924, a year of light injury. The plots reported on were located in Pulaski, Mississippi, Chicot, and Miller Counties, representing, central, northeastern, southeastern, and southwestern Arkansas respectively. In none of these locations were the plots under consideration in situations subject to the most severe form of weevil injury, since in no case were they in situations subject to attack by overwintered weevils. The experimental fields were invaded by migrating weevils, in 1923 by midsummer. The invasion was later in 1924 and one of the experimental series escaped weevil injury altogether. All varieties yielded more in 1924 than in 1923. However, in 1923 the year or severe weevil injury, the extra early varieties yielded 69.25 per cent more seed cotton than the late varieties and slightly more than the medium early varieties. In 1924 the early varieties produced only 18.61 per cent more seed cotton than the late varieties, and slightly less than the medium early varieties. The difference between the extra early varieties and the late varieties was 50.64 per cent greater during the year of severe weevil injury than during the year of light injury.

*Research Paper No. 354, Journal Series, University of Arkansas.

[1]Ware, J. O. Cotton variety experiments. Ark. Agr. Exp. Sta. Bul. 197, 27p. 1925.

Attempts to measure the advantages of relative earliness of cotton with respect to boll weevil injury by field plot experiments have been carried on intermittently by the Department of Entomology since 1926. The data secured while not as full as desired are presented here because of the improbability of the continuance of the work with the present shortage of funds.

Controlled field plot experiments were carried on in 1926 and repeated in 1927 on the farm of the Arkansas Agricultural Experiment Station at Fayetteville. These plots were not affected by migrations of weevils from adjacent fields since no cotton was grown commercially in their immediate vicinity. The plots involved replications of a typical early, a typical medium early, and a typical late variety. One half of the plots was dusted in an attempt to remove the factor of weevil injury and the other half was left untreated. The arrangement of these plots was in a checkerboard form, with no plot occupying exactly the same situation, in two adjacent rows.

The varieties used in this experiment in 1926 were, a strain of Trice as representative of very early cotton, an early strain of Acala, as representative of medium early cotton, and Snowflake as representative of late varieties. In 1927 a late strain of Rowden was substituted for Snowflake. In 1926 there were twelve plots, four of each variety; in 1927 there were twenty-four plots, 8 of each variety. The comparative earliness of these varieties is shown by counts of the average number of bolls on 100 feet of the row made approximately a month after the beginning of square formation. These averages are shown in Table 1.

TABLE 1. AVERAGE NUMBER OF BOLLS TO 100 FT. OF ROW OF THREE VARIETIES OF COTTON, ONE MONTH AFTER FIRST SQUARE FORMATION

Year	Variety		
	Early	Medium early	Late
1926	606	448	303
1927	347	319	220

Although cotton was planted on the same date each year, May 17 and 18, the two seasons were quite different in their effect on the rate of development of squares. Cotton grew more slowly in the beginning of 1926 and formation of squares did not begin until near the middle of July. The summer and fall were relatively dry and warm and fruiting continued unusually late in the season. In 1927 the square formation began about July 2 and the summer was relatively humid.

The manner in which the plots were infested also differed for the two years. In 1926, on August 11 and again on August 18, sixty newly-transformed weevils were released in the middle of each plot. The plots

were evenly infested by September 1. In 1927, the infestation occurred naturally by the overwintered progeny of weevils liberated in 1926. The early infestation was somewhat less evenly distributed than in 1926. The weevil infestations in the two years, although heavier than average, do not represent extreme conditions.

In 1926 four dust applications were made between September 3 and September 15, too late to be of much value in an ordinary season. In 1927 three dust applications were made between August 16 and August 25.

The differences in yield between the dusted and undusted plots are shown in Table 2. These differences do not account for all the weevil injury. They show clearly, however, that late varieties carry a much greater weevil hazard, and also that there is less to be gained by dusting early rapidly maturing cotton.

TABLE 2. COMPARATIVE GAINS BY DUSTING EARLY, MEDIUM, AND LATE MATURING VARIETIES OF COTTON AS SHOWN BY RATE OF YIELD OF SEED COTTON PER ACRE. FAYETTEVILLE, ARKANSAS

Year	Variety type	Average yield, pounds of seed cotton per acre. (Computed)		Average gain in pounds by weevil control	Per cent gain in yield by weevil control
		Undusted plots	Dusted plots		
1926	Early.....	1159	1403	244	21.1
	Medium early..	660	942	282	42.7
	Late.....	483	1063	580	120.1
1927	Early.....	869	1097	238	27.4
	Medium early..	652	768	116	17.8
	Late.....	520	776	256	49.2

A similar type of experiment was conducted at the Branch Experiment Station at Hope, Arkansas, in 1929.[2] In this instance the variety test plots of the Agronomy Department were used. In these plots the varieties tested occurred in four contiguous series. Two series were dusted and two were left undusted.

The infestation of overwintered weevils on these plots was scattered but light. When the first generation matured a fairly evenly distributed infestation appeared. A series of three dust applications was made beginning in the latter part of July when the number of squares punctured reached about 35 per cent. Severe drought during August checked weevil injury but also checked late fruiting of cotton. In contrast to the previous experiments such weevil injury as occurred was relatively early.

[2]Thanks for cooperation are due to J. O. Ware, Agronomist in charge of cotton varietal experiments and to G. W. Ware, Assistant Director in charge of the Branch Experiment Station at Hope, Arkansas.

The gains in pounds of seed cotton harvested on the 42 dusted and 42 undusted plots of 21 varieties or strains are shown in table 3. The per cent of earliness is based on the per cent of the total crop harvested at the first picking. Since drought checked the late development of cotton there is a larger percentage of early cotton than average; also the degree of weevil damage is less than average. The yields were affected by factors other than weevil injury, particularly by variable drought resistance of the different strains. Nevertheless, there is a marked tendency for the gains of yield due to weevil control to increase with the lateness of the varieties in question. It should also be noted that the highest yield of undusted cotton with one exception was produced by the earliest varieties.

TABLE 3. COMPARATIVE GAINS BY DUSTING COTTON VARIETIES OF DIFFERENT DEGREE OF EARLINESS AS SHOWN BY YIELD OF SEED COTTON PER ACRE. HOPE, ARK., 1929

Per cent earliness	Number of varieties	Number of plots	Average yield, pounds of seed cotton per acre. (Computed) Undusted plots	Dusted plots	Average gain in pounds by weevil control	Per cent gain in yield by weevil control
95 to 100	2	8	709	928	219	30.9
90 to 95	0	—	—	—	—	—
85 to 90	5	20	616	869	253	41.1
80 to 85	4	16	647	993	346	53.5
75 to 80	2	8	740	994	254	34.3
70 to 75	3	12	657	1049	392	59.8
65 to 70	5	20	685	988	303	44.2

While the conditions in each set of experiments described were different, the results in one particular were the same in that the earliest varieties always suffered the least weevil injury. This adds confirmation to the widely accepted belief that very early varieties of cotton are least subject to weevil injury. It also justifies the recommendation of planting only the earliest varieties in situations where a regular annual hazard from overwintered weevils occurs. Such situations constitute only a small part of the cotton acreage of Arkansas, probably less than 5 per cent of the total. Where weevils do not regularly invade a field until midsummer, the medium early varieties may be grown to advantage if they are desirable for other reasons. On the light sandy uplands of southwestern Arkansas, where sudden checking of growth by drought frequently occurs, both weevil injury and the plant growth tends to be small. Under such conditions the factor of earliness can probably be ignored in the selection of a variety. The degree of emphasis which it should receive in the greater part of the state depends on local conditions.

It may also be concluded that dusting to control the weevil is less

necessary, or less advantageous on early than on later varieties. Planters who do not expect to dust for weevil control should give more attention to the earliness of the varieties used.

It should be recognized that the natural fruiting period of a variety is greatly modified by the moisture supply, the soil type, and the soil management. Thus varieties which usually have a long fruiting period in the bottoms may have a short almost determinate fruiting period in the light sandy uplands.

None of these experiments represented conditions of extreme weevil injury. In dusting experiments carried on by the Department of Entomology where weevil control has been the only purpose, the gains from dusting have averaged approximately 120 per cent. Plots used in such experiments were always located in midsummer and in the midst of heavy infestations. Under such conditions the advantage of earliness would doubtless be much greater than any shown by the experiments reported in this paper. Where plots must be located before the planting season, as must always be done when varieties are to be compared, weevil infestations are less dependable and often not evenly distributed enough to be suitable for experimental comparisons. This is also of significance since it shows that the importance of the factor of earliness in a large part of the cotton acreage of Arkansas can be overrated.

An extra early variety, particularly if it germinates well and is relatively hardy to cold in the seedling stage, may have further use in weevil control as a trap crop in concentrating infestations of overwintered weevils. A trap crop is of value only in situations where early infestations of overwintered weevils are known to occur annually.

Where the use of a trap crop has been tried by the writer, it has been planted somewhat earlier than the main variety. A degree of cold hardiness is desirable for this reason. Hardy strains of Trice and Express have been used. Overwintered weevils tend to concentrate on cotton plants which begin fruiting first, and for this reason the early infestations were largely or altogether concentrated on the trap plantings. In our experiments this sharp difference between the degree of infestation of the trap variety and the main planting has always justified early dusting of the trap crop and for the time being ignoring the remainder.

INSECTS OF STORED RICE IN LOUISIANA AND THEIR CONTROL

By CHAS. L. STRACENER, *Assistant in Entomology, Louisiana Experiment Station*

When the study of insects affecting stored rice in the rice area of Louisiana was begun in July 1932, it was found that little had been done along this line in the state; and, unfortunately, the records of even the little work done were destroyed in our Experiment Station fire of 1921. A study of literature on weevil damage in this country failed to show that any work had been published by any of our rice producing states along the line of weevil control work in rice.

It was desirable to know as nearly as possible the extent of damage done to stored rice, and the nature of this damage as well as the insects responsible for the loss; so our first work was directed along this line. Early in September 1932 samples of rice of the 1931 crop were collected from the warehouses over the entire rice area of the state, some eighty-five samples being collected, which included samples of the different varieties when possible; and a thorough study made in the laboratory to determine the extent, nature, etc. of the damage done and the insects responsible. Later when the 1932 crop was being harvested, samples were taken from the separators and examined immediately when brought to the laboratory for any insects that might be in the rice when harvested. These samples were at once placed in separate 1 qt. glass jars without rubbers and closed to prevent outside infestation. Samples of the 1932 crop were also collected from the warehouses for a study of the spread of infestation in comparison with that from the fields. These collections were made about January 30, April 5, June 20, and August 13, 1933. The samples of the first two dates were kept in jars also. Samples were collected from the warehouses in early September (Sept. 7–9) for comparison with those of the previous year for damage.

The study of these various samples shows that considerable loss is sustained by the rice growers of Louisiana. The average infestation for the 1931 crop when carried through August was slightly above 20 per cent, with a total loss in weight of 16 per cent. The total loss for the same period on the 1932 crop was 14 per cent, the lower loss rate being due to the more severe winter of 1932 and 1933. This loss, when figured on the twelve year average of rice production in the state with current prices (1920–1932) and on the yearly average of marketing of the rice crop, would total in round numbers, a million dollars to the rice industry annually.

The loss to rice through insect damage in Louisiana is due principally to three species of insects named in order of the damage done: the Lesser Grain Borer, *Rhizopertha dominica* Fab., Angoumois grain moth, *Sitotroga cerealella* Oliv., and the Rice, or black weevil, *Sitophilus oryzae* L. Other species found in rice which are responsible for some loss in cleaned rice are: the Cadelle, *Tenebroides mauritanicus* L., Confused flour beetle, *Tribolium confusum* Duv., Flat grain beetle, *Laemophloeus minutus* Oliv., Square-necked grain beetle, *Cathartus quadricollis* Guer., and the Saw-toothed grain beetle, *Oryzaephilus surinamensis* L., with a few other species rarely found. The three first species named are responsible for more than 95 per cent of the damage done rough rice, all being free fliers and will fly away readily when molested. Each species will readily attack uninfested grain and will multiply rapidly under favorable conditions. The Cadelle will also attack uninfested rough grain, but prefers the cleaned rice. Probably all the less important species named depend on other insects to break through the rough covering of the grain or feed only on hulled grains.

A study of the samples stored in jars during the season indicates that the real spread of infestation is in the warehouses. Only 8 per cent of samples collected from the fields developed any infestation, while 17.5 per cent of the samples collected from the warehouses in late January, 47.7 per cent collected in early April, and 97.4 per cent collected the middle of June developed insects. This shows that a small percentage of infestation comes from the field and that the spread in the warehouse is very rapid, reaching almost all rice stored by the middle of June. The study shows further that the average infestation for the middle of June was 3.5 per cent of all samples collected, while that for September was slightly above 16 per cent. It was noted that the September infestation of samples collected in June was but 12 per cent, the same for samples collected in April, 9 per cent, and those collected in January 5.5 per cent. These figures are the average of only the samples showing infestation. This shows a gradual spread of infestation under warehouse conditions not to be found under control conditions. This may be due to the fact that some species multiply more rapidly than others. These facts would point to a possible control in the warehouses by coordinating a time for fumigation in the warehouses with other conditions. It should be done late enough in the season so that the bulk of rice would already have been milled and at the same time early enough so that the damage loss by weevils would be small and that the new crop in the field would not be advanced to the stage where field infestation would be possible.

The fumigation of the entire crop under present conditions is both impractical and impossible. The warehouses are very large open shed-like structures with floors and side-walls very open, therefore, any fumigation will have to be done in specially prepared rooms. The rice will have to be carted in for treatment, which will increase the cost of treatment. Statistics obtained from The American Rice Millers Association shows that an average of only about 10 to 15 per cent of the crop remains unmilled after June 1 to June 15. It should be observed that infestation is low at this time and the stock of rough rice in storage is low also and further that at this period the early rices have not yet begun to head in the field. It may be seen that fumigation at this point would probably mean practical control if practiced by all warehouses and if the very small crop of corn in the area is also treated.

This treatment would necessitate the tightening up of all warehouse floors so that no rice would be left in the floors after sweeping to harbor weevils and so that a disinfectant might reach any insect on the floor. A tight room of sufficient capacity to handle the rough rice in storage at this time would have to be provided at each warehouse, and cooperation as to time of treatment by each warehouse in any locality would have to be practiced. If all rice remaining in the warehouse at this time should be treated with some good fumigant and the floors thoroughly cleaned up and the waste burned or fumigated and the floors treated with a good disinfectant, so many weevils would be destroyed that very few would be left to spread to the surrounding fields later. This spread ordinarily takes place as the rice is removed from the warehouses. It, probably, would be necessary to fumigate any rice remaining in the warehouse just before the new crop is placed in storage.

The question of a fumigant that is effective, cheap, and at the same time safe is a very important one just now. You have a problem of penetration with rough rice, especially since it is sacked in 185 to 200 pound bags in Louisiana, and tests show that rice in the "paddy" is very resistant to the penetration of heat and gases. This phase has not been thoroughly worked out yet. Carbon-disulphide has always been effective, comparatively cheap, and will penetrate the bag of rice probably better than most other fumigants; but it is not used frequently because of the danger of fire, Chloropicrin is more frequently used but the penetration into the sack is not so good and it is disagreeable to use because of irritation to the eyes and the throat and lungs. Hydrocyanic acid gas is not practical because of the extreme danger to the user and the penetration is poor. There are other fumigants that may be used with fairly satisfactory results, but they are more expensive and less effective.

It has been known for some time that carbon-dioxide when used in combination with other fumigants has increased the toxicity of the fumigant by its stimulation of the respiratory functions and it has been demonstrated by Jones[1] that it also counteracted the combustibility of certain inflammable fumigants such as carbon-disulphide. We were conducting experiments along this line here at the Louisiana Experiment Station when it was learned that this problem was being worked out by Mr. Jones. We found that carbon-disulphide is non-inflammable when used at the rate of 5½ pounds per 1000 cubic feet and mixed when in the gaseous state with about 4½ times its volume of carbon-dioxide, and is also thoroughly toxic to the cadelle both larval and adult stages. The cadelle is the most difficult insect to kill of any species attacking stored grain.

There are different ways by which carbon-dioxide may be mixed with carbon-disulphide or other inflammable fumigants. The carbon-disulphide may be atomized by the carbon-dioxide gas under pressure, but a considerable drop in temperature results both in the carbon-dioxide when the pressure is released and in the carbon-disulphide when passing into vapor form. This tends to hinder the diffusion to some extent and to reduce the toxicity to insects. The combination may be made also by pouring the carbon-disulphide over "dry ice" or carbon-dioxide in the solid or frozen form, after it has been crushed in small granules; but in this case loss occurs, and the cooling effect would be the same as with the gas combination. Another method of mixture is obtained by the generation of carbon-dioxide through chemical reaction when bicarbonate of soda is mixed with a dilute acid. For convenience in handling and the advantage obtained otherwise, we have found that the carbon-disulphide may be poured directly into the bicarbonate of soda without chemical combination or deterioration other than the usual evaporation if left exposed to air; and the proportion of carbon-disulphide to the bicarbonate of soda is such that the latter is not saturated to any extent. The dilute acid may be added to this mixture and the chemical reaction that takes place between the acid and bicarbonate of soda is in no way hindered by the presence of the carbon-disulphide and the evolution of gas tends to vaporize the carbon-disulphide. Thus the two are liberated simultaneously. It is observed that no carbon-disulphide is left in the liquid form after the reaction takes place.

Tests were made in the laboratory with this combination of gases, using 5½ by 8 inch glass battery jars over which tin friction top can lids

[1]R. M. Jones, Industrial and Engineering Chemistry. Vol. 25, page 394, April 1933.

were placed for covers. These covers were not air tight and, probably, give no better results than would heavy papers or tarpaulins fastened tightly over a barrel or tank top. Cadelles, both adult and larval stages, and confused flour beetles were used as test specimens. This combination with varying amounts of carbon-disulphide ranging down to as low a rate as 1.4 pounds per 1000 cubic feet gave 100 per cent kill in 24 hours in our battery jar tests.

FURTHER EXPERIMENTS IN THE CONTROL OF THE PEACH BORER ON NURSERY STOCK AND ORCHARD TREES

By OLIVER I. SNAPP and J. R. THOMSON, *Bureau of Entomology, United States Department of Agriculture*

Experiments on the use of emulsions of crude cottonseed oil and of mineral oil impregnated with paradichlorobenzene in the control of the peach borer (*Aegeria exitiosa* Say), especially on young trees, have been continued in confirmation of results reported 2 years ago.[1] Considerable work has also been done with ethylene dichloride for the control of this insect. The suggestion, on the basis of circumstantial evidence, that the peach borer may spread the phony disease of the peach emphasizes the importance of the control of the peach borer, especially in nursery stock.

EXPERIMENTS IN 1932.—Emulsions of paradichlorobenzine-crude cottonseed oil and paradichlorobenzene-mineral oil (viscosity, 80 seconds Saybolt) at various strengths were used on trees 1, 2, 3, and 7 years old during the fall of 1932. The emulsions were made by dissolving paradichlorobenzene in the oil in the proportion of 2 pounds of the chemical to each gallon of oil and then emulsifying the mixture with a good grade of potash-fish oil soap. The stock emulsions were then diluted with water so that ½ or 1 pint contained the desired dosage of paradichlorobenzene for each tree. The emulsions were sprayed on the ground around the tree and on the lower part of the trunk. The trees were mounded after treatment by placing several shovelfuls of soil around each tree to prevent surface loss of the chemical. For purposes of comparison a few young trees were treated with paradichlorobenzene crystals and with mineral-oil emulsion. Three examinations for tree injury were made, in the fall of 1932 and in the spring and summer of 1933. Table 1 gives the results of these experiments.

[1]Snapp, O. I. A new method of controlling the peach borer, *Synanthedon exitiosa* Say, with special application to young trees. J. Econ. Ent. 25:786–799. 1932.

The percentage of larvae dead from the treatments is really higher than the figures given in the table, as many of the very small larvae could not be found after they had decomposed. A few larvae were removed with the hoe when the soil around the trees was taken away to permit examination. Evidently some larvae were forced out of the trees by the treatment and died on the outside, as a few were found in the soil, gum, and frass around the tree.

Crude cottonseed oil has a higher viscosity and a lower vapor pressure than the mineral oil used, and on that account retains the paradichlorobenzene better. An emulsion of mineral oil carrying paradichlorobenzene is therefore more likely to injure the tree, but it should give more rapid and perhaps higher mortality of peach-borer larvae than an emulsion of crude cottonseed oil carrying paradichlorobenzene.

One borer in the trunk 8 inches above the soil level was killed with the paradichlorobenzene-mineral oil treatment, and this would not have occurred if the usual crystal treatment had been used. No tree injury resulted from treating 1- and 2-year-old trees with paradichlorobenzene crystals and very little from treating 3-year-old trees with that material. Weather conditions in the fall of 1932 did not favor rapid evaporation of paradichlorobenzene crystals or an accumulation of gas under a charge of crystals. Rains were not frequent enough to prevent the gas from diffusing through the soil as it was given off from the crystals, and temperatures were not high enough to cause an abnormal generation of gas from the crystals.

EXPERIMENTS IN 1933. *Effect of various treatments on nursery stock.*—During the last week in February 1933 a large number of experiments were conducted in an effort to eliminate the peach borer in nursery stock by dipping, by placing the stock in sawdust impregnated with paradichlorobenzene, and by fumigation. In the first series of experiments June-budded nursery stock was given one of the following treatments: (1) Dipped for 15 minutes in paradichlorobenzene-crude cotton seed oil emulsion at 3.125, 6.25, and 12.5 per cent strengths; (2) dipped in paradichlorobenzene-mineral oil emulsion at the same strength; (3) placed in sawdust saturated with these emulsions at 3.125 and 12.5 per cent strengths; (4) placed in shallow furrows and then covered with a layer of dry sawdust, after which the sawdust was sprayed with those emulsions at 3.125 and 12.5 per cent strengths; (5) fumigated for 1 hour and 2 hours with hydrocyanic acid gas generated from potassium cyanide at the rate of 1 ounce per 100 cubic feet; and (6) fumigated for 15 hours with calcium cyanide dust at the rate of 1½ ounces per 100 cubic feet. Unfortunately for the experiments, the stock was found to be

free from borers. The nursery stock was not injured by the paradichlorobenzene-crude cottonseed oil dips, the paradichlorobenzene-mineral oil dips at 3.125 and 6.25 per cent strengths, or the fumigants, but more or less injury resulted from the other materials.

As the June-budded nursery stock was free from borers, the dipping experiments were repeated in March with older nursery stock from Georgia and Tennessee that was thought to contain borers. The potassium cyanide was used at the rate of 2 ounces per 100 cubic feet for 1 hour, and the calcium cyanide at the rate of 4 ounces per 100 cubic feet for 15 hours. The dips caused no injury to this stock, but they did not kill all the borers. Either the treatment was not long enough or the weather following the treatment was too cold for rapid evolution of gas. The fumigants did not kill the borers or cause tree injury. The other treatments caused more or less tree injury and did not kill all the borers.

In April experiments were conducted with the same dips for 1 hour's duration, and with the fumigants at the rate of 2 ounces per 100 cubic feet for 3 hours for the potassium cyanide and 6 ounces per 100 cubic feet for 15 hours for the calcium cyanide. There was no injury from the paradichlorobenzene-crude cottonseed oil dips. A dead borer was found in one of the trees dipped in the 12.5 per cent emulsion. The 12.5 per cent paradichlorobenzene-mineral oil dip caused some tree injury. There was no injury from the fumigants. Unfortunately, there were very few borers in the stock used for this series of experiments.

Treatments of orchard trees with ethylene dichloride and carbon tetrachloride.—During the spring of 1933 a large number of experiments were conducted to determine the value of ethylene dichloride and carbon tetrachloride for the control of the peach borer in 10-year-old trees. Ethylene dichloride applied at the rate of 2 fluid ounces per tree and covered with soil killed all the borers and caused no tree injury. Three fluid ounces of that material also killed all the borers but caused severe injury in some cases. A 1-ounce dose killed 81.8 per cent of the borers. Rather poor control was obtained in cases where the ethylene dichloride was not covered with soil or was covered with water, and this material was not effective against the eggs. An emulsion of ethylene dichloride carrying 1 or 2 fluid ounces of the active ingredient to each tree gave good control of the borers but caused slight injury to several trees. One fluid ounce of ethylene dichloride in which 33.3 per cent by weight of paradichlorobenzene had been dissolved killed about three-fourths of the borers at each concentration. In some cases dead borers were at a considerable distance below the soil level and in other cases there were dead

TABLE 1. RESULTS OF EXPERIMENTS WITH PARADICHLOROBENZENE-OIL EMULSIONS, APPLIED AS SPRAYS FOR THE CONTROL OF THE PEACH BORER, FORT VALLEY, GA., 1932

(Applications made October 10–15)

Material used	Paradichlorobenzene carried to each tree	Age of trees	Number of trees in plat	Number of weeks after treatment (or date) examined for borers	Number of borers found	Mortality, per cent	Injury to trees
Paradichlorobenzene-crude cottonseed oil emulsion	¼ oz.	1 year	(*)	(*)	0	—	None.
		2 years	5	2	1	100	A few flecks in bark around wounds on 1 tree.
			5	4	0	—	A very few flecks around wounds on 2 trees.
			5	8	1	100	None.
			5	April 1933	0	—	None.
	½ oz.	2 years	5	2	1	100	Slight injury at hoe wound on 1 tree.
		3 years	5	2	0	—	Slight injury at hoe wound on 1 tree.
			5	4	7	100	A little injury at hoe wound on 2 trees.
			5	8	0	—	None.
			5	April 1933	1	100	Flecks in bark layers at wounds on 2 trees.
	¾ oz.	7 years	5	2	23	83	None.
			5	4	19	100	None.
			5	8	14	86	None.
			5	April 1933	0	—	None.
	¼ oz.	1 year	5	2	0	—	Severe injury into cambium at wounds on 2 trees.
			5	4	7	100	None.
			5	8	0	—	None.
			5	April 1933	0	—	None.
		2 years	5	2	4	100	Slight injury at small hoe wound on 1 tree.
			5	4	7	100	None.
			5	8	1	100	None.
			5	April 1933	0	—	Serious injury to 1 tree, where oil entered wound.

Paradichlorobenzene-mineral oil emulsion	½ oz.	2 years	5	2	6	100	Injury into cambium at one place on each of 2 trees.
		3 years	5	2	5	100	None.
			5	4	3	100	Flecks in bark layers of 2 trees and into cambium of 1 tree.
			5	8	2	100	A very few flecks in bark layers of 2 trees.
			5	April 1933	1	100	Injury into cambium at wounds on 2 trees; flecks in bark layers on 1 tree.
	¾ oz.	7 years	5	2	6	100	Severe injury to cambium at large hoe wound on 1 tree.
			5	4	16	100	None.
			5	8	14	86	None.
			5	April 1933	0	—	Some apparent oil injury above decayed areas on 3 trees.
Mineral-oil emulsion at comparable dosages	——	1 year	3	8	0	—	None.
		2 years	3	8	1	0	None.
		3 years	3	8	2	0	None.
Paradichlorobenzene crystals	¼ oz.	1 year	3	4	0	—	None.
	½ oz.	2 years	3	4	0	—	None.
		3 years	3	8	0	—	A few flecks in bark layers on 1 tree.
Untreated	——	1 year	9	December 1932	3	0	None.
		2 years	10	December 1932	11	0	None.
		3 years	5	December 1932	2	0	None.
		7 years	5	December 1932	30	3	None.

*4 plats of 5 trees each, examined, respectively, 2, 4, and 8 weeks after treatment and in April 1933.

borers above the soil level, indicating good penetration and diffusion of the ethylene dichloride gas.

Carbon tetrachloride was not so effective as ethylene dichloride for control of the peach borer and, furthermore, was more toxic to the trees.

The results of this work indicated that ethylene dichloride might be an effective and safe means of controlling the peach borer and therefore warranted further experimentation to include nursery stock as well as orchard trees.

Treatments of nursery stock and orchard trees with paradichlorobenzene-oil emulsion sprays.—In the fall of 1933 the experiments with paradichlorobenzene-crude cottonseed oil emulsion and paradichlorobenzene-mineral oil emulsion applied as sprays were continued on an extensive scale which included nursery stock and orchard peach trees 1, 2, 3, 4, 5, and 6 years old. These emulsions were tested by spraying a mere shot or ½ or 1 pint around the base of the tree including the lower part of the trunk. Paradichlorobenzene-gasoline emulsion, paradichlorobenzene-kerosene oil emulsion, ethylene dichloride, and a shot each of 33.3 per cent and 50 per cent ethylene dichloride emulsions were also used on a number of trees of each age.

An emulsion of crude cottonseed oil impregnated with paradichlorobenzene carrying 1/16 ounce of the chemical to each tree was found to be safe on nursery stock and effective against the borer. A mere shot of the emulsion containing 1/8 or ¼ ounce of paradichlorobenzene in each ½ pint of spray gave 100 per cent control with no tree injury. Paradichlorobenzene-crude cottonseed oil emulsion carrying as little as $^1/_{24}$ ounce of paradichlorobenzene in each pint of spray killed more than 99 per cent of peach borer eggs, so the above strengths of that emulsion will destroy peach borer eggs that may be on the trees when the spray is applied for the elimination of the larvae.

An emulsion of mineral oil impregnated with paradichlorobenzene sprayed around nursery stock gave as good control of the borers as the paradichlorobenzene-crude cottonseed oil emulsion, but was not so safe owing to the fact that mineral oil liberates the paradichlorobenzene more rapidly than does crude cottonseed oil. Some flecking of nursery stock occurred when the mineral-oil emulsion carrying only 1/16 ounce of paradichlorobenzene was used. Although it is cheaper than the spray containing vegetable oil, it cannot be recommended on account of tree injury.

Paradichlorobenzene-gasoline emulsion and paradichlorobenzene-kerosene oil emulsions carrying 1/16 or 1/8 ounce of paradichlorobenzene to each tree caused serious injury to the cambium of nursery stock. A

shot of 33.3 or 50 per cent ethylene dichloride emulsion caused serious injury to nursery stock, as did ¼ fluid ounce of ethylene dichloride poured around each nursery tree. There was no injury to nursery stock from the 1/8-ounce dose.

Paradichlorobenzene-crude cottonseed oil emulsion carrying 1/8 ounce of paradichlorobenzene to 1- and 2-year old orchard trees, ¼ ounce to 3-, 4-, and 5-year-old trees, and ½ ounce to 6-year-old trees caused no tree injury. The emulsion at these strengths gave a 100 per cent control of the borers in 3-year-old trees, 81.8 per cent control in 4-year-old trees, 85.7 per cent control in 5-year-old trees, and 100 per cent control in 6-year- old trees. There were no borers in the 1- and 2-year-old trees.

A shot of paradichlorobenzene-crude cottonseed oil emulsion containing ¼ ounce of paradichlorobenzene in each pint of spray caused no injury to 1- and 2-year-old orchard trees. There were no borers in these trees. A shot of the emulsion containing ½ ounce of paradichlorobenzene in each pint of spray caused no injury to 3-, 4-, and 5-year-old trees, and gave a 100 per cent control of the borers in 3- and 5-year-old trees and a 75 per cent control in 4-year-old trees. A shot of the emulsion carrying ¾ ounce of paradichlorobenzene in each pint of spray caused no injury to 6-year-old trees and gave a 77.8 per cent control.

Paradichlorobenzene-mineral oil emulsion carrying 1/8 ounce of paradichlorobenzene to 1- and 2-year-old trees, ¼ ounce to 3-, 4-, and 5-year-old trees, and ½ ounce to 6-year-old trees caused no injury. The emulsion at these strengths gave a 66.7 per cent control of the borers in 4-year-old trees and a 100 per cent control in 6-year-old trees. There were no borers in the trees 1, 2, 3, and 5 years old.

A shot of paradichlorobenzene-mineral oil emulsion containing ¼ ounce of paradichlorobenzene in each pint of spray caused no injury to 1- and 2-year-old orchard trees. There were no borers in these trees. A shot of emulsion containing ½ ounce of paradichlorobenzene in each pint of spray caused no injury to 3-, 4-, and 5-year-old trees, and gave 58.3 per cent control in 4-year-old trees and 100 per cent control in 5-year-old trees. There were no borers in the 3-year-old trees. A shot of the emulsion carrying ¾ ounce of paradichlorobenzene in each pint of spray caused no injury to 6-year-old trees and gave a 65.2 per cent control.

Paradichlorobenzene-gasoline emulsion and paradichlorobenzene-kerosene emulsion carrying 1/8 ounce of paradichlorobenzene to 1- and 2-year-old trees, ¼ ounce to 3-, 4-, and 5-year-old trees, and ½ ounce to 6-year-old trees gave a 100 per cent control of the borers but caused

serious injury to the bark layers and cambium of orchard trees of those ages.

Ethylene dichloride at the rate of ¼ or ½ fluid ounce poured around each 1-year-old orchard tree caused no injury. There were no borers in these trees. A ½- or ¾-ounce dose of that material around 2-year-old orchard trees gave a 100 per cent control and no tree injury. The ¾-ounce dose did not injure 3-year-old trees, but a 1-ounce dose caused some injury to the bark layers. There were no borers in these 3-year-old trees. A 1-ounce dose did not injure 4- or 5-year-old trees and gave a 100 per cent control. One and one-half ounces also killed all the borers in 4- and 5-year-old trees but injured the cambium of more than half of the 4-year-old trees and the bark layers of most of the 5-year-old trees. The 1½-ounce dose caused no injury to 6-year-old trees and killed 92.3 per cent of the borers. A 2-ounce dose of ethylene dichloride killed all the borers but caused slight injury in the bark of over half of the 6-year-old trees.

A shot of 33.3 per cent or 50 per cent ethylene dichloride emulsion gave a 100 per cent control of the borers in each case where there were borers in orchard trees 1, 2, 3, 4, 5, and 6 years old but caused injury to the bark of some 2-, 3-, and 5-year-old trees and injury into the cambium of some 4- and 6-year-old trees.

Time of application.—The best results were obtained from paradichlorobenzene-crude cottonseed oil emulsion when applied at the end of the oviposition period of the moth, which is October 10 to 15 for central Georgia. Applications made 2 weeks later resulted in lower borer mortality, undoubtedly owing to the retarding effect of the lower temperatures on the active ingredient. The late treatment carrying 1/16 ounce of paradichlorobenzene to nursery stock killed only 66.7 per cent of the borers. There were no borers in the 1- and 2-year-old orchard trees that received the late treatment. The late treatment carrying ¼ ounce of paradichlorobenzene to each tree killed 50 per cent of the borers in 3-year-old trees, 75 percent in 4-year-old trees, and 66.7 per cent in 5-year-old trees. The late treatment carrying ½ ounce of paradichlorobenzene to each tree killed 75 per cent of the borers in 6-year-old trees. There was no tree injury from any of these late treatments.

Recommended Method.—The results of these experiments indicate that an emulsion of crude cottonseed oil impregnated with paradichlorobenzene, applied as spray around the base of the tree and on the lower part of the trunk, is effective against the peach borer in nursery stock and orchard trees and causes no tree injury at strengths sufficient to kill the borers. Nursery stock should receive ½ pint of the emulsion

carrying 1/16 ounce of paradichlorobenzene to each tree, and orchard trees should receive ½ pint of the emulsion carrying 1/8 ounce of paradichlorobenzene to each 1- and 2-year-old tree, ¼ ounce of paradichlorobenzene to each 3-year-old tree, and ½ ounce of paradichlorobenzene to each 4- and 5-year-old tree. Peach trees 6 years of age and older should receive 1 pint of the emulsion carrying ¾ ounce of paradichlorobenzene to each tree. These dosages will kill peach-borer eggs as well as the larvae. The application should be made at the end of the oviposition period of the moth and the spray should be covered with several shovelfuls of soil to prevent surface loss. This method is inexpensive, as the materials for spraying 1,000 nursery trees will cost only about two dollars.

This method appears effective and safe for the control of the peach borer in nursery stock and in 1-, 2-, and 3-year-old orchard trees under conditions in the South. It is an improvement over the old paradichlorobenzene crystal treatment for orchard trees of other ages, as it is easier to apply, requires less time for the application, and is cheaper, requiring less paradichlorobenzene to cause borer mortality. The spray has another advantage over paradichlorobenzene crystals in that mounds of earth placed around trees after the application need no further attention, whereas in the case of the crystal treatment it is advisable to tear down the mounds to remove unspent crystals and allow the confined gas to escape as a precaution against tree injury. The spray has been found effective in some cases where there were borers in the crotch of the tree and in the trunk as high as 8 inches above the ground.

THE WOOLLY APHIS IN TENNESSEE[1]

By S. MARCOVITCH, *Entomologist, Tennessee Agricultural Experiment Station*

The woolly aphis (*Eriosoma lanigerum* Hausman) is a well-known pest wherever apples are grown. This insect is sometimes very abundant in southern nurseries, causing the roots to become swollen and covered with nodules, which finally decay. Fifty per cent of the trees in the nursery may often be seriously infested. Such trees have to be discarded because of the weakened root system and the chances of spreading the aphis to the newly set orchard. Bearing trees in the orchard may also be infested, although the injury is not so apparent. This in-

[1]The author desires to acknowledge the valuable assistance of Mr. M. V. Anthony in these experiments.

vestigation was originally started for the purpose of finding out more about the woolly aphis in the nursery, where the problem is most serious.

EFFECT OF TEMPERATURE ON THE GROWTH AND DEVELOPMENT OF THE WOOLLY APHIS.—Often during the summer months no aphids could be found of either the aerial or the root form, even though heavy infestations were observed in the early summer or spring months. Since this disappearance seemed to occur especially during hot, drouthy summers, a study of the temperature requirements was undertaken.

METHODS USED IN REARING.—Seedling apple trees one or two years old were placed in jars of water. Transfers were made to these seedlings, which were then placed in the cabinets at various temperatures. At 30°C. only one or two generations could be reared before the trees died. A simple method of making the transfers was to start with a bearing female. After the first young were produced, the adult female was removed.

STUDIES AT CONSTANT TEMPERATURES.—The data are summarized in Table 1. The optimum condition for growth and development seems to be near 20°C. At this temperature the maximum number of 119 young were produced by each female, over a reproductive period of 18.5 days. Reproduction began at 14.5 days. At 25°C. the average number of young produced was 93.5.

At 30°C. only 6.6 young were produced over a period of 9.2 days. Clearly, this temperature is not very favorable for development. Difficulty was experienced in rearing them and large numbers perished.

TABLE 1. RECORD OF REPRODUCTIVE CAPACITY OF *E. lanigerum* AT CONSTANT TEMPERATURES

Temperature °C.	Temperature °F.	Number of adults used	Average age when first young produced	Reciprocal	Mean reproduction period	Average total number of young produced	Average number of young produced per day
15	59	15	22.7	4.40	29.3	117.6	4
20	68	17	14.5	6.89	18.5	119	6.4
25	77	20	8.8	11.49	18.1	93.5	5.2
30	86	16	14.7	6.80	9.2	6.6	0.7

TABLE 2. SHOWING 100 PER CENT MORTALITY IN HOURS, PRODUCED BY A TEMPERATURE OF 100°F. AND VARIABLE HUMIDITIES

Age of aphids	Number of aphids	40 per cent R. H.	Number of aphids	80 per cent R. H.	Number of aphids	100 per cent R. H.
Aphids 1 or 2 days old....	76	⅔	22	4¾	19	2½
Half-grown to full-grown...	333	1¼	142	7	371	2½

MORTALITY IN A CONSTANT TEMPERATURE OF 100°F. AND VARIABLE HUMIDITIES.—At a constant temperature of 100°F. and 80 per cent

relative humidity, young aphids lived only 4¾ hours and half-grown ones lived 7 hours. At 50 per cent relative humidity the young survived for only 40 minutes, while older ones lived 75 minutes. A relative humidity of 100 per cent was also unfavorable, for the aphids survived but 2½ hours.

SOIL TEMPERATURES.—Practically each summer, high temperatures prevail, ranging from 90°F. to 98°F. In a series of observations a maximum of 113°F. was recorded in the gravelly loam soil of the nursery at a depth of 2 inches, while at 6 inches the temperature was 102°F. The air temperature 24 inches above the soil was 102°F.

The data from the temperature cabinets indicate that temperatures of 85°F. to 100°F. are highly unfavorable for development. Since these temperatures occur frequently each summer, it is easy to understand why we have the all but practical disappearance of the woolly aphis during the summer months. A few individuals, however, survive these unfavorable conditions, for as soon as cooler weather prevails, accompanied by rain, the woolly aphis becomes evident. Two-year-old trees are always more heavily infested than the small one-year-old trees, perhaps due to the heavier shade produced by the larger trees.

RELATION TO THE ELM.—The first conspicuous infestations of the woolly aphis becomes apparent in June soon after the migration from the elm. It is hard to conceive how the nursery can become infested if no elm migrants are present, unless the nurseryman uses infested scions or roots. One year we actually found woolly aphis on roots, shipped in from Kansas. If precautions are taken to free the roots and scions from aphis, the only source of infestation remains the progeny resulting from the elm migrants.

In Tennessee a large number of apple nurseries are located at Winchester. In 1925 small elm trees were found grown as nursery stock beside a block of one-year-old apple trees. Three large rosettes were present in April on these elms and contained thousands of aphids and migrants ready to fly to the apple. Interplantings of this nature offer ideal conditions for the multiplication of the pest.

A survey also revealed a large elm tree covered with rosettes in a creek bottom on the farm of Mr. Vanzant. This elm was less than a quarter of a mile from an apple nursery. It is needless to remark that one badly infested elm may supply enough migrants to infest an entire locality where apple trees are grown.

INSECTICIDES.—Like other aphids, the aerial form of the woolly aphis readily succumbed to nicotine, 1–1000, and soap, 3 pounds to 100 gallons of water. The root form represents a much more difficult

problem, and nicotine at the rate of 1–2000 with penetrol, when 3 pints per square foot was used, did not seem to be thoroughly effective.

Paradichlorobenzene seemed to destroy the aphids when as little as 1/8 ounce per tree was used. Because of the thin bark on apple, however, paradichlorobenzene is apt to cause injury to the tree under favorable conditions. In California, Essig found that paradichlorobenzene did not injure nursery trees. Paranitrochlorobenzene, as little as 1/16 ounce, killed the aphids, but was injurious to the tree.

Cory (1923) and Schoene (1922) used 5 and 8 per cent solutions of pine-tar oils successfully. Our tests with this material gave variable results. Other remedies recommended in the past, such as tobacco stems and kerosene emulsion, have been found worthless.

Carbon disulphid, ½ ounce to 4 gallons of water, applied at the rate of ¾ gallon per square foot, will control the root form of the woolly aphis (Leach, 1928). More recently a carbon disulphid emulsion has been used very successfully for the larvae of the Japanese beetle. In our work we used an emulsion supplied by I. P. Thomas Company, of Philadelphia, at a cost of about 20 cents a pound. The emulsion is a mixture of carbon disulphid, castor oil, potassium hydroxide, alcohol, and water, and is said to be stable.

Against the woolly aphis this carbon disulphid emulsion seemed to give the best control. When applied at the rate of ½ pint diluted 1–50, or 1½ pints 1–200, the aphis disappeared in the sandy soils. Heavier soils or dry soils require more material to get control.

Because of the cost and large amount of water required, carbon disulphid emulsion would not be practical in the nursery. Material to treat one acre of a nursery would cost $130.00. For the newly set orchard, it may be of value whenever a heavy infestation warrants treatment.

Influence of Soil Type on Infestation.—In 1922 apple grafts were grown in the greenhouse for observation of the woolly aphis. Although aerial forms were plentiful, no root forms could be found. The absence of lice on the roots was puzzling. In order to account for this condition, if possible, a study of the moisture and character of the soil was made.

Experiments with different degrees of soil moisture revealed no decided difference on the degree of infestation. In another set of experiments in the greenhouse the grafts were grown in a sandy soil, sandy loam, clay loam, and clay soils. Eight per cent of the trees in the sandy soil showed root aphis, while in the clay soil 92 per cent were infested.

In order that the character of the soil under outdoor conditions might be studied, trenches in every other row were dug in the nursery, some being filled with a sandy loam and others with a clay soil. The residual soil varies from a silty to gravelly loam. Some of the trees were also mulched with a 3-inch layer of sand.

TABLE 3. INFLUENCE OF THE CHARACTER OF THE SOIL ON THE ABUNDANCE OF THE ROOT FORM OF THE WOOLLY APHIS

Soil type	Number of trees	Per cent infested	Degree of infestation
Clay	31	96.7	Heavy
Silt loam	115	89.5	Heavy
Clay and gravelly loam	149	43.0	Moderate
Clay loam mulched with sand	93	14.5	Slight
Sandy loam	33	3.0	Slight

As shown in Table 3, the highest infestation, 96.7 per cent, was present in the clay soil. The residual silt loam which also cracks badly in dry weather showed 89.5 per cent infestation, and residual gravelly loam had 43 per cent. The latter soil when mulched with three inches of sandy loam showed only 14.5 per cent infestation. In the trench filled with a sandy loam, only one tree or three per cent was but slightly infested.

As is well known, clay soils crack badly, and it therefore appears that the aphis enters the soil through the cracks and becomes established on the roots. It was observed in the laboratory that a clay or silt soil will, in the process of drying, crack over one-eighth inch away from the roots. This, in turn, gives the aphids more room to move about than would be possible in a sandy soil.

In 1913, Woodworth called attention to the desirability of preventing the migration of the lice from the roots, and recommended that a few shovels of soil be removed around the tree and replaced with sand.

Mordvilko (1927), working in Russia, observed that the phylloxera can not live on the roots of vines in sandy soils. In the few cases, where the vine aphis was found on the roots, Mordvilko observed that heavy winds, by agitating the aerial portion of the tree, caused cavities near the trunk, by means of which the aphis entered the soil. He also explains the presence of the *Eriosoma lanigerum* on the roots as due to wind pressure and the formation of cracks.

In California, Nougaret and Lapham (1928) likewise observed that phylloxera infestation is most frequent on soils of heavy texture, which bake and crack when dry. They point out that heavy soils, by cracking, afford more crevices and interstices for free movement of the insect. On the other hand, the Madera, Oakley, and Fresno sandy loams are free from phylloxera infestation and practically immune.

The same phenomenon for the woolly aphis is mentioned by Newcomer (1933). He points out that the aphis is unimportant in the sandy areas of the Northwest, whereas deformities on the roots are found on trees growing in heavy soils.

Summary

1. The woolly aphis (*Eriosoma lanigerum*), a native American insect, is an important pest of the apple in Tennessee, especially on nursery stock.

2. Where the woolly aphis is present, the roots become knotted and finally decay. Trees with a badly knotted root system are not saleable.

3. A constant temperature of about 68°F. seems to be near the optimum for growth and development. At a constant temperature of 100°F. and 40 per cent relative humidity the young survived only 40 minutes. Since soil temperatures often reach 100°F. or over, the mortality produced in the summer is high. During hot drouthy summers the root forms seem to disappear almost entirely.

4. Since elm trees are the principal source of infestation, they should be destroyed when present near nurseries. If this can not be done, the rosettes should be removed before April 20.

5. Among the different insecticides used, paradichlorobenzene, paranitrochlorobenzene, nicotine, pine-tar creosote, and carbon disulphid emulsion, the last seems to be the most promising, and practical only in the newly set orchard.

6. Root infestation takes place by the migration of the aerial forms through cracks in the soil. Trees grown in sandy soils, which do not crack, are comparatively free from root trouble. Mulching with three inches of sand also effectively reduced the number of woolly aphis on the roots and should be a practical measure for the newly set orchard.

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A PRELIMINARY REPORT ON THE USE OF CREOSOTE OIL (WOOD OIL) TO CONTROL SAN JOSE SCALE AND PEACH LEAF CURL

By W. W. STANLEY, S. MARCOVITCH, and J. O. ANDES, *Tennessee Agricultural Experiment Station*

Creosote oil emulsions obtained from coal tar have been advocated by several English entomologists as dormant washes against the overwintering stages of injurious insects on fruit trees. They seem to be particularly valuable for their ovicidal properties, in which the commonly used insecticides are deficient. Tests with tar distillate emulsions are now being conducted in America. A report of such work has been recently published by Hartzell and Parrott as Bulletin No. 636 of the New York Agricultural Experiment Station.

In our work we used a crude wood creosote oil from the Tennessee Eastman Corporation, located at Kingsport, Tennessee. We were especially interested in testing the scalecidal and fungicidal properties. The disease-inhibiting power of creosote washes used as dormant sprays on fruit trees seems to have been neglected. The work on the ovicidal properties is now in progress.

COMPOSITION AND PHYSICAL PROPERTIES.—The chemical and physical properties of the creosote oil as submitted by the Tennessee Eastman Corporation are as follows:

Creosote oil is a mixture of oils formed during the destructive distillation of hardwoods. Chemically, they are a complex mixture of phenols, cresols, guaiacols, xylenols and ethers of pyrogallol.

These oils in the crude form are brownish-black in color and have a characteristic, burnt, phenolic odor. At 15.6°C. the specific gravity varies between 1.060 and 1.090. A typical boiling range of these oils is as follows:

First Drop–141°C.
141–200°C.— 6.0%
200–225°C.—13.0
225–300°C.—52.0
300–340°C.—29.0

Other characteristics, both physical and chemical, are as follows:

Toxicity—Poisonous if taken internally, but no harmful effects such as burns, etc., result from handling these oils or accidentally allowing them to get on the skin, etc.

Moisture content—Free from water.

Miscibility—Immiscible with water, miscible with alcohol, ether, etc.

Viscosity (Saybolt)—120 seconds at 100°F.

Flash point—172.0°F.

Ignition point—220.0°F.

Phenol coefficient (Rideal-Walker)—4.00.
Caustic solubility (indicates phenol content)—46.60%.
Acidity as acetic acid—0.40%.

Chemical compounds that have been definitely identified in these oils are alcohols, phenols and derivatives, aldehydes, ketones, acids, bases, hydrocarbons, and furans.

EXPERIMENTS IN 1931 AND 1932.—Emulsification of creosote oil was at first difficult. Emulsions made with sodium hydroxide or Grandpa's Wonder soap were satisfactory but difficult to prepare. A 10-gallon hand-pump with a pressure of about 100 pounds was used to apply the sprays on peach trees.

Observations showed that concentrations from 2½ per cent to 10 per cent gave good control of peach leaf curl, and considerable control of San Jose scale and terrapin scale. Sprays containing as much as 13½ per cent creosote oil were found to be safe on dormant peach trees.

EXPERIMENTS IN 1932 AND 1933.—Laboratory tests showed that powdered lignin pitch could be used as an emulsifying agent. All creosote oil sprays used in 1932–1933 were emulsified with powdered lignin pitch, which proved a more desirable material than either sodium hydroxide or Grandpa's Wonder soap.

In preparing a stock emulsion of creosote oil for orchard sprays, the following formula was used:

Water	1½ gallons
Powdered lignin pitch	3.6 pounds
Creosote oil	3 gallons

The powdered lignin pitch was dissolved in hot water, and creosote oil slowly added while the materials were forced through a hand-pump. The emulsion when pumped through the hand-pump three times did not break down when exposed to freezing temperatures.

The sprays were applied at 300-pounds pressure with a power sprayer, on favorable days between January 14 and January 26. Data on San Jose scale and peach leaf curl were obtained by counting approximately 900 scales and leaves on representative twigs sprayed with each material.

The results show that control of San Jose scale and peach leaf curl with creosote oil is proportional to the strength of spray solution. A two per cent creosote oil gave no control of San Jose scale, but effective control of peach leaf curl. One per cent creosote oil gave 64.19% control of peach leaf curl. Eight per cent creosote oil gave 91.09% control of San Jose scale and 95.54% control of peach leaf curl. The most effective control secured against San Jose scale was obtained by using both creosote oil and oil emulsion. The spray containing 1% creosote

TABLE 1. SUMMARY OF DATA OBTAINED IN 1933 FROM USE OF MATERIALS TO CONTROL SAN JOSE SCALE AND PEACH LEAF CURL

Material	Per cent control of San Jose scale	Per cent control of Peach leaf curl
1% Creosote oil	——	64.19
2% Creosote oil	54.91	89.92
4% Creosote oil	81.34	94.25
8% Creosote oil	91.09	96.54
1% Creosote oil plus 3% oil emulsion	99.08	97.96
2% Creosote oil plus 2% oil emulsion	98.40	94.71
3% Creosote oil plus 1% oil emulsion	97.65	92.17
3% Oil emulsion plus Bordeaux 2–4–50	——	99.38
2% Coal tar distillate	——	94.52
4% Coal tar distillate	——	96.55
3% Coal tar distillate	76.26	——
6% Coal tar distillate	86.03	——
3% Oil emulsion	84.77	——
Check	60.52	9.64

oil plus 3% oil emulsion gave 99.08% control of San Jose scale. Three per cent oil emulsion gave 84.77%, while a 2% solution of creosote oil alone showed no control at all.

Excellent control of peach leaf curl also resulted in the use of mixtures of creosote oil and oil emulsion. One per cent creosote oil and 3% oil emulsion gave 97.96% control of peach leaf curl, while a 1% solution of only creosote oil gave 64.19% control. Coal tar distillate (Arbo) showed about the same toxicity to San Jose scale and peach leaf curl as creosote oil at similar strengths. Bordeaux (2–4–50) gave 99.38% control. By using Fisher's method of T to test the significance of means, it was found that the following materials were equally effective against peach leaf curl: Bordeaux (2–4–50), 1% creosote oil plus 3% oil emulsion, 2% creosote oil plus 3% oil emulsion, 4% and 8% of creosote oil alone. Using the same method, we found that mixtures of creosote oil and oil emulsion were equally effective against San Jose scale.

POSSIBLE USES OF CREOSOTE OIL.—These preliminary tests indicate that creosote oil is toxic to the San Jose scale and peach leaf curl. Used with oil emulsion, the toxicity is increased, producing a synergistic effect. The wood creosote oil seems to be as toxic as the coal tar washes, without the corresponding burning effects produced in handling them.

Although the value of coal tar creosote oils as an insecticide has been known for some time, their fungicidal properties when used as dormant washes seem not to have been stressed. The striking results produced against peach leaf curl may be indicative of the possible value of creosote oil against other diseases that hibernate on fruit trees, such as blotch, fire blight, scab, and others. It is within the realm of possibility that a 12% creosote oil used as a dormant wash would sterilize an orchard, producing results that might be noticeable for years.

One per cent creosote oil as a summer application was used without foliage injury on apples, peaches, beans, tobacco, and cucumbers. Two per cent, however, caused severe burning.

CONCLUSIONS.—Creosote oil is very toxic to San Jose scale and peach leaf curl, and the control obtained was in direct proportion to the amount of creosote oil in the spray.

Mixtures of creosote oil and oil emulsion are much more toxic to San Jose scale and peach leaf curl than when the materials are used separately, producing a synergistic effect.

SUGARCANE BORER CONTROL BY TRICHOGRAMMA IN LOUISIANA, 1933

By W. E. HINDS, B. A. OSTERBERGER and A. L. DUGAS

Four phases of the sugar cane borer control work of 1933 will be emphasized and correlated in this report. These include (1) the progress of parasitism in test areas to the middle of September; (2) determinations of stands of millable and unmillable cane with borer infestation and moth emergence therein; (3) analyses of representative 30-stalk samples taken at about November 1; and (4) plantation records showing yields and analyses for various test areas, with final figures on sugar per acre.

(1) PROGRESS OF PARASITISM.—The colonized and check areas established June 12–15, at the beginning of the second borer generation, are grouped under "Series I" (see Tables 1 and 2), and another set started at about August 1 upon the eggs for the third generation are grouped under "Series II" (see Table 3). The significant data for Series I regarding Progress of Parasitism are shown in Tables 1 and 2 following.

A study of the figures in Tables 1 and 2 shows that at the middle of June borer eggs were about three times as abundant in early corn areas as in the cane at the same date, and more than twice as abundant to the last week of July when the corn was maturing and becoming unattractive for further oviposition. During the period from June 15 to 25, it seems that climatic conditions were unfavorable in some respect for borer egg deposition and, accordingly, unfavorable for *Trichogramma* multiplication. However, sufficient advantage in *Trichogramma* establishment was maintained in colonized areas of both corn and cane that when the borer eggs for the third generation became abundant about August 1, the parasites increased much more rapidly in colonized and adjacent areas than they did in the checks. However,

this increased parasitism in "protected" areas was not as marked as it was under the more favorable conditions of 1932, and the maximum or peak of parasitism at the middle of September was never found to be as high in any field as was found in the average of all June colonized fields in 1932. By far the fastest and greatest gains in egg parasitism were made very consistently in colonized areas.

At the peak of egg parasitism in 1932, among 12 colonized fields an average of 96.4% of the eggs were being destroyed as compared with an average of 74.8% in the 12 June colonized fields for 1933.

TABLE 1. PROGRESS OF *Trichogramma* PARASITISM IN *Early Corn*, 1933. EGGS OF *Diatraea saccharalis*—PART OF SERIES 1. 5000–6000 *Trichogramma* PER ACRE RELEASED IN COLONIZED AREAS AFTER JUNE COLLECTION

Test and number of fields averaged	Basic records	Collection numbers and periods: Collection 1 6/7–14	Collection 2 7/4–7	Collection 3 7/24–26	Final gain over start
Checks	Total eggs collected	3,492	1,831	2,101	
	Average number eggs per 1 man-hr	499	366	525	
7–5–4	Total eggs parasitized	639	456	349	
	Average per cent parasitized	18.3	24.9	16.6	—1.7
Colonized	Total eggs collected	5,382	1,738	4,621	
	Average number eggs per 1 man-hr	598	217	924	
9–8–8	Total eggs parasitized	490	207	2,163	
	Average per cent parasitized	9.1	11.9	46.8	+37.7

TABLE 2. PROGRESS OF *Trichogramma* PARASITISM IN *Cane*, 1933. EGGS OF *Diatraea saccharalis*. PART OF SERIES 1. 5000–6000 *Trichogramma* PER ACRE RELEASED IN COLONIZED AREAS AFTER JUNE COLLECTION

Test and number of fields averaged	Basic records	Collection numbers and periods: Collection 1 6/7–15	Collection 2 7/4–7	Collection 3 7/ 24–26	Collection 4 8/ 14–16	Collection 5 9/5–6	Final gain over start
Checks	Total eggs collected	2,321	3,045	6,258	7,610	16,520	
	Average number eggs per 1 man-hr.	193.4	234	481	573	1,271	
13	Total eggs parasitized	12	45	971	3,384	10,819	
	Average per cent parasitized	0.5	1.5	15.5	44.4	65.5	+65.0
Adjacent to colonized fields 5	Total eggs collected	1,001	311	1,019	3,248	4,929	
	Average number eggs per 1 man-hr	200	62	204	650	986	
	Total eggs parasitized	7	0	8	1,839	3,870	
	Average per cent parasitized	0.7	0.0	0.8	56.6	78.5	+77.8
Colonized 6/12–15 12	Total eggs collected	1,984	1,116	4,164	7,898	15,410	
	Average number eggs per 1 man-hr.	180	93	345	658	1,284	
	Total eggs parasitized	5	67	650	5,249	11,532	
	Average per cent parasitized	0.25	6.0	15.6	66.5	74.8	+74.55

TABLE 3. PROGRESS OF *Trichogramma* PARASITISM IN *Cane*, 1933. EGGS OF *Diatraea saccharalis*—PART OF SERIES 2. 10,000 *Trichogramma* PER ACRE RELEASED IN COLONIZED AREAS AFTER AUG. 1–3 COLLECTION

Test and number of fields averaged	Basic records	Collection numbers and periods			Final gain over start
		Collection 1 7/31 –8/3	Collection 2 8/ 21–24	Collection 3 9/ 11–13	
Checks (16)	Total eggs collected	15,193	22,775	63,277	
	Average number eggs per 1 m—hour	950	1,423	4,218	—
	Total eggs parasitized	4,594	13,174	53,866	
	Average per cent parasitized	30.2	57.8	85.1	+54.9
Adjacent (2)	Total eggs collected	1,055	3,526	9,067	
	Average number eggs per 1m—hour	578	1,763	4,534	
	Total eggs parasitized	495	2,674	8,606	
	Average per cent parasitized	46.9	75.8	94.9	+48.0
Colonized (28)	Total eggs collected	23,160	48,604	117,371	
	Average number eggs per 1 m—hour	965	1,676	4,192	
	Total eggs parasitized	4,969	36,026	110,812	
	Average per cent parasitized	21.4	74.1	94.4	+73.0

TABLE 4. COMPARISON OF PEAK OF PARASITISM 1932 VS. 1933

Year	Checks		Adjacent		Colonized	
	Number fields	Average per cent parasitized	Number fields	Average per cent parasitized	Number fields	Average per cent parasitized
1932	21	69.3	18	93.2	12	96.4
Series 1 1933	12	65.5	5	78.5	12	74.8
Series 2 1933	15	85.1	2	94.9	28	94.4

The August 1 colonized fields (Series 2) contained an abundant supply of borer eggs and show a rapid increase in parasitism in both Colonized and Adjacent fields which is very closely comparable with that occurring in June colonizations in 1932. These figures for the three collections made are shown in Tables 3, 4, and 5. Further significant information is shown in Table 5 following.

In spite of the much lower per cent of natural parasitism in colonized areas at start, the release of 10,000 Trichogramma per acre very promptly (within 3 weeks) overcame this handicap and put these fields even with the so-called "adjacent" fields which were far more heavily parasitized at August 1. From the second collection to the third examination 9/11–13, the colonized and adjacents ran away from the checks.

It is of interest and significance to find that in colonized and check corn fields, from July 4 to 26, 1933, from 45 to 55% of the 499 egg batches taken were 100% parasitized. With cane plats in Series 1, over 75% of the batches were completely destroyed. Among Series 2

TABLE 5. *Diatraea* VS. *Trichogramma*—1933. PROGRESS OF *Trichogramma* PARASITISM. SERIES 2. RELEASED 10,000 *Trichogramma* PER ACRE IN COLONIZED CUTS—AUG. 1, COLONIZATIONS

Period 1933	Number cuts	Type of test	Total Eggs examined	Total Eggs parasitized	Per cent parasitized, average	Gain in per cent parasitism over start 8/1
7/31–8/3	16	Check	15,193	4,594	30.2	—
8/21–24	16	Check	22,775	13,174	57.8	27.6
9/11–13	15	Check	63.277	53,866	85.1	54.9
7/31–8/3	2	Adjacent	1,055	495	46.9	—
8/21–24	2	Adjacent	3,526	2,674	75.8	28.9
9/11–13	2	Adjacent	9,067	8,606	94.9	48.0
7/31–8/3	24	Colonized	23,160	4,969	21.4	—
8/21–24	29	Colonized	48,604	36,026	74.1	52.7
9/11–13	28	Colonized	117,371	110,812	94.4	73.0

colonized cane fields, 85% of all egg batches found at September 11–13 examination were completely parasitized.

BORER INFESTATION IN CANE.—In studying the effect of egg parasitism upon the emergence of moths and upon the percentage of joints bored we find results that are entirely consistent with those of preceding years. These records relate only to cane.

TABLE 6. DIATRAEA INFESTATION IN CHECK AND COLONIZED FIELDS IN MILLABLE CANE ONLY

Test	Number fields averaged	Total stalks number	Total joints number	Per cent joints bored	Per cent stalks bored	Number emerged holes	Average stalks number per 1 moth	Approximate No. moths per A. season
Series 1								
Checks...	12	1,200	15,660	21.4	88.0	468	2.57	9,189
Colonized	15	1,500	20,235	13.6	80.0	225	6.67	4,062
Series 2								
Checks...	15	1,500	16,980	32.8	99.0	900	1.67	12,582
Colonized.	30	3,000	35,100	24.3	95.0	900	3.33	7,408

Analysis of figures given in Table 6 shows a very slight increase in length for the average stalks in the 4500 examined from 45 colonized fields. This amounted to 0.2 joint per stalk in 1933.

In the column showing percentage of joints bored there is a difference of 7.8% in favor of the colonized in Series 1 and 8.5% in Series 2. These differences amount to an average decrease of 30% in the proportion of joints showing any borer burrows among 45 colonized fields. This difference is certainly significant. Similar reduction in the proportion of joints bored has appeared consistently during the work of the past three seasons when it has been measured.

A close study of the borer moth population produced in millable cane during the season of 1933, as indicated by counts of emergence holes,

shows an even greater reduction in the number of moths produced in colonized areas than the reduction in bored joints. We have not split open stalks to confirm our diagnosis of "emergence holes." It is possible that some which we have counted as emergence holes were really large entrance holes made by practically full-grown larvae, but if this were done it would mean that our figures as to numbers of moths produced per acre are really higher than they should have been. The possible error on this point will not affect the comparisons shown between different groups of fields.

The effect of *Trichogramma* colonization upon the proportion of the original stand of cane that developed to millable size and condition is significant and yields an important comparison showing the value of early season colonization. The data is shown in Table 7 below. The stand is computed to acre bases from all of the field sample records showing the number of millable and unmillable stalks found per 100 row-ft. and all comparable records for each set of fields added together.

TABLE 7. *Diatraea* vs. *Trichogramma*—1933. RELATIONSHIP OF ORIGINAL STAND TO MILLABLE CANE. AVERAGE OF ALL RECORDS FOR EACH GROUP

Series	Starting dates 1933	Number fields averaged	Stand-Stalks Original stand per A.	Harvested number	Per cent Harvested	Type of test
1	6/15	14	34,080	27,094	80.0	Colonized
1	6/15	12	32,240	23,616	73.5	Checks
2	8/1	30	37,520	24,669	66.0	Colonized
2	8/1	15	37,520	21,011	56.0	Checks

In Series 1 cane fields the original stand was 1840 stalks per acre greater in the average of 14 colonized fields than in the average of 12 check fields. The number of millable stalks was increased to 3478 stalks. In Series 2 the original stand was equal but in colonized fields an average of 10% more stalks were millable. These figures indicate an increase of millable cane amounting to from 1 to 1½ tons per acre on the average where colonized. With the heavier borer infestation occurring in 1932, the mill records showed a difference in average yield of over three tons per acre in favor of the colonized areas.

EFFECT UPON ANALYSES OF CANE SAMPLES.—In order to determine the effect of *Trichogramma* colonization upon the analyses of cane samples taken from as many test areas as possible, 30-stalk samples were taken at about November 1st. The method used in taking these samples has been found, through years of experience by Mr. Taggart, to be the most reliable and easily practicable method which he has tried. One man, Mr. Dugas, took all of these samples. One stalk at a spot is taken at random, but widely scattered through the field, until thirty stalks are

secured. All are stripped and topped uniformly. Samples are carefully counted, tied and labelled, kept in the shade and brought by truck to Baton Rouge, where they are run through the small mill at the Sugar House. Weights of stalks and juice are made by one man and the analyses run immediately by the sugar chemist. Comparisons of analyses representing test and check areas by these methods are, we believe, more strictly comparable and accurate than can be obtained by plantation records at harvest time.

A fairly good test of this sampling method is obtained by comparing the average figures for "pounds of sugar per ton of cane" thus obtained with the figures shown by mill records when the plats were harvested. Such a comparison shows by mill records an increase of 0.83 lb. of sugar per ton of cane on the average for 29 areas at harvest time above the average for 26 areas sampled by the method described at about November first. This small increase might be expected from later harvested cane.

The most significant correlations and results for the season are shown together in Table 8.

The gain in "pounds of sugar per ton of cane" in 1932 averaged for all tests 20.92 lbs. In 1933, June colonizations show 19.79 lbs. gain, and August first colonizations show 15.13 lbs. gain.

These records appear to be very consistent.

Plantation Reports for Test Areas, 1933

There are many difficulties in the way of getting dependable and complete plantation records on yields and analyses. Only records which we believe to be dependable are included in this final set of records. Our sincere thanks are due to many plantation owners, managers, superintendents, chemists and field foremen for their cooperation and help in getting for us these records which show comparisons in "sugar per acre."

Most of our tests in 1933 were made on 1st stubble cane and the yield average is rather low. However the average figures for each variety and the composite weighted averages for colonized and check groups, are, we believe, very consistent and dependable. The composite increase in sugar per acre is 355.42 lbs.

The value of sugar for 1933 is taken at 3½ cents per pound. This gives an average increase in gross value of sugar per acre amounting to $12.44 for all 18 colonized areas according to plantation reports.

The cost of colonization averaged $1.00 per acre. This leaves an average net profit of $11.44 per acre for the *Trichogramma* field colonization work of 1933, when borer infestation was much less than in 1932.

TABLE 8. *Diatraea* vs. *Trichogramma*—1933—GENERAL SUMMARY PROGRESS OF PARASITISM, INFESTATION, YIELDS AND SUGAR PER TON

SERIES 1. JUNE COLONIZATIONS

Type field	Per cent eggs parasitized 6/7 to 6/15	7/4 to 7/7	7/24 to 7/26	8/14 to 8/16	9/5 to 9/6	Average infestation, 100 per cut. Number stalks exmd.	Per cent stalks bored	Per cent joints bored	Average number emerged holes per 100 stalks	Stand per A. Millable stalks	Unmillable stalks	Number fields average	Analyses average Sucrose average per cent	Pounds of sugar per ton cane
(Col.)														
Protect.	6.7	9.6	31.9	66.5	74.8	1,500	80.0	13.6	15	27,094	6,986	9	12.38	163.98
Checks	11.2	10.3	15.7	44.4	65.5	1,200	88.0	21.4	39	23,616	8,624	7	11.37	144.19
Difference ± for colonized areas							—8.0	—7.8	—24	+3,478	—1,638	16	+1.01	+19.79

SERIES 2. AUGUST COLONIZATIONS

Type field	Per cent eggs parasitized 7/31 to 8/3	8/21 to 8/24	9/11 to 9/13	Average infestation, 100 per cut Number stalks exmd.	Per cent stalks bored	Per cent joints bored	Average number emerged holes per 100 stalks	Stand per A. Millable stalks	Unmillable stalks	Number fields average	Analyses average Sucrose average per cent	Pounds of sugar per ton cane
(Col.)												
Protect.....	21.4	74.1	94.4	3,000	95.0	24.3	30	24,669	12,851	24	11.91	156.11
Checks.....	30.2	57.8	85.1	1,500	99.0	32.8	60	21,011	16,509	14	11.00	140.98
Difference ± for colonized areas					—4.0	—8.5	—30	+3,658	—3,658	38	+.91	+15.13

TABLE 9. *Diatraea* CONTROL BY *Trichogramma*—1933. VALUE OF SAVING IN SUGAR PER ACRE FROM *Trichogramma* COL'N. AS SHOWN BY PLANTATION RECORDS ON FIELD YIELDS AND ANALYSES

Location, La.	Variety	Yield per acre, tons	Pounds of sugar per ton cane	Pounds sugar per acre	Pounds sugar gain per acre from protection	Saving per acre at 3½c sugar
		Protected fields: Colonized				
Hope A1	213 St.	13.00	158.59	2,061.67		
Hope A2	213 St.	13.22	153.89	2,034.43		
Hope A3	213 St.	13.81	158.85	2,193.72		
Hope B1	213 St.	13.10	125.97	1,650.21		
Hope B2	213 St.	14.00	161.64	2,262.96		
Hope B3	213 St.	13.91	155.02	2,156.33		
LeMaire 6	213 St.	15.00	167.42	2,511.30		
Albania A1	213 St.	11.33	152.80	1,731.22		
Albania A2	213 St.	11.33	159.76	1,810.08		
Albania A3	213 St.	11.33	155.00	1,756.15		
Albania A4	213 St.	11.33	156.00	1,767.48		
Adeline 1	213 P.	25.25	130.81	3,302.95		
Average	213	13.88	152.98	2,103.21	249.51	$8.73
Arlington 1	234 St.	13.26	168.12	2,229.27		
Arlington 2	234 St.	13.26	180.57	2,394.36		
Albania 1	234 St.	14.50	178.56	2,589.12		
Albania 2	234 St.	14.50	175.26	2,541.27		
LeMaire 2	234 P.	23.75	202.33	4,805.34		
Average	234	15.85	180.97	2,911.87	610.13	$21.35
LeMaire 4	807 St.	26.00	169.77	4,414.02	1,186.40	$41.52
Composite weighted av.		15.10	161.69	2,456.22	355.42	$12.44
		Check fields, natural parasitism				
Hope B4	213 St.	13.46	150.29	2,022.90		
Hope B5	213 St.	13.09	141.87	1,857.08		
LeMaire 7	213 St.	12.00	155.47	1,865.64		
Albania B2	213 St.	10.57	157.88	1,668.79		
Albania B3	213 St.	10.57	151.29	1,599.14		
Albania B4	213 St.	10.57	131.63	1,391.33		
Adeline 2	213 P.	22.31	115.24	2,571.00		
Average	213	13.22	143.38	1,853.70		
Arlington 3	234 St.	13.07	136.03	1,777.91		
Albania 3	234 St.	14.50	162.41	2,354.95		
LeMaire 3	234 P.	18.00	154.02	2,772.36		
Average	234	15.19	150.82	2,301.74		
LeMaire 5	807 St.	22.00	146.71	3,227.62		
Composite weighted av. cks.		14.56	145.71	2,100.80		

EXPERIMENTS WITH SUCTION LIGHT TRAPS FOR COMBATING THE CIGARETTE BEETLE

By W. D. Reed, A. W. Morrill, Jr., and Erskine M. Livingstone, *Bureau of Entomology, United States Department of Agriculture*

The cigarette beetle adult (*Lasioderma serricorne* Fab.) spends most of its life in semidarkness or diffused daylight. It responds positively to light of a moderate degree of intensity, although it is repelled by brilliant lights, such as sunlight and electric lights of 100 watt capacity or greater. Tobacco dealers and manufacturers for years have observed this behavior of the insect, particularly during the emergence of the different broods during the summer. Toward sunset or on cloudy days, when the intensity of the light is low, the adults congregate by the hundreds on the skylights and windows of heavily infested storages. This phenomenon can best be obesrved from about 5 P.M. until darkness during the periods of the year in which the adults of the broods are emerging. Many of the beetles migrate from the warehouses in which they have developed and disperse to other tobacco factories and warehouses in the vicinity, and it is during these migration periods that they are attracted to light in the largest numbers.

Types of Light Traps Observed.—For many years tobacconists have used various devices and materials for trapping the cigarette beetle in order to reduce the population of this insect in tobacco warehouses of the bright tobacco belt.

During the summer the skylights and windows of tobacco warehouses are sometimes covered with cylinder oil, castor oil, tanglefoot, or cup grease in which to catch the cigarette beetles that gather there, and hundreds of dead beetles have been observed imbedded in these materials. In some instances traps consisting of barrels or boxes lined with fly paper and fitted with electric lights are used. The sticky fly paper used in these devices consists of sheets 14 by 8 inches, and the highest average number of beetles observed in one of these traps was 611 per sheet. Another type of trap consists of individual sheets of fly paper, 14 by 8 inches, fastened to boards and suspended beneath electric lights in warehouses. The lights over these boards are burned during the night, and the largest weekly catch observed on one trap has been 1,856 beetles. Although these devices destroy large numbers of cigarette beetles, they are ineffective as control measures and should not be relied upon for combating this insect.

Suction Light Trap.—During the summer of 1932, with the cooperation of the tobacco industry, a trap combining light and suction was

tested in tobacco warehouses. The trap (Figs. 75 and 76) is composed of a sheet metal cylinder in which is fastened a 1/20 H.P. motor with fan blades attached. A brief description of the suction light trap follows:

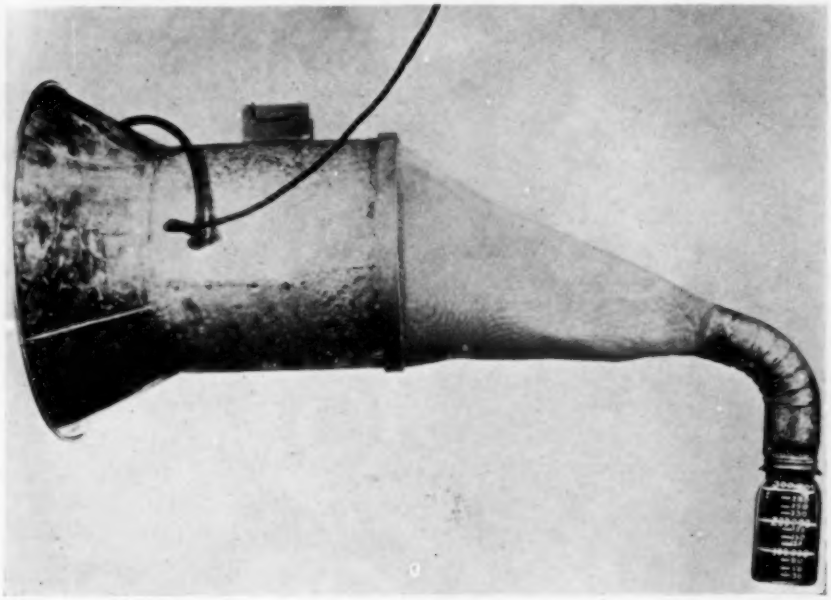

Fig. 75.—Horizontal view of suction light trap, showing the screen cone and glass jar for collecting the insects, and the galvanized iron collar attaching the screen cone to the barrel of the trap.

Barrel: 12 inches long and 13 inches in diameter, constructed of galvanized iron. Bracket of 16 gauge flat iron riveted inside centrally, to which the motor is fastened by stove bolts.

Motor: 1/20 H. P. motor, totally enclosed type, wired to correspond to wiring of warehouse. Fan twelve inches in diameter, containing two blades.

Reflector: Blocked tin, soldered to front end of barrel and extending 6 inches from barrel.

Trap: Twenty-mesh bright steel or copper screen wire cone, fastened to rear end of barrel by a metal collar made of galvanized iron. Tin elbow 3 inches in diameter soldered to neck of cone to accommodate glass jar for collecting the insects.

Hangers: Metal or wire ring soldered to top of barrel, front and back, so that trap can be suspended from the ceiling in tobacco warehouses.

Light: Light socket fastened inside the reflector as shown in Fig. 76. Splice made in light cord to operate motor and light from a double socket.

A modification of the trap, as described, has also been tested and found to be effective for trapping beetles. A cheesecloth bag 22 by 34 inches, fastened by a drawstring, was used, instead of the wire cone

and glass jar, for collecting the insects. Although the use of cheesecloth is more economical, the traps with the bags attached require closer supervision and the catches of insects are more difficult to handle.

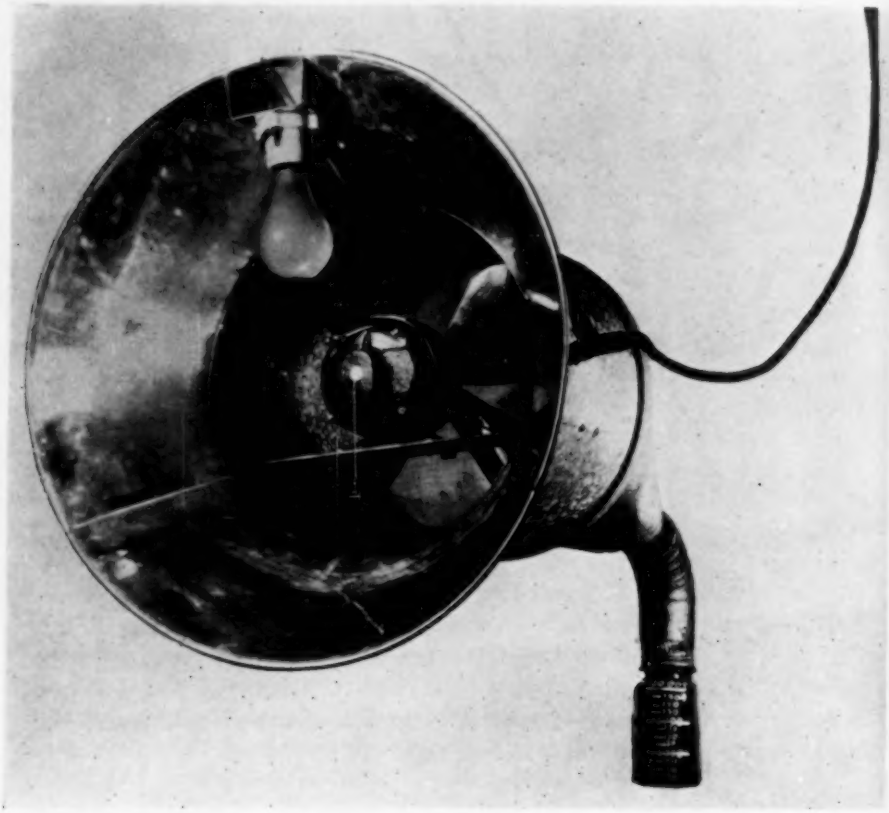

Fig. 76.—Front view of suction light trap, showing position of the 1/30 H. P. motor in the barrel and the electric connections to motor and light.

OPERATION.—The trap is designed to operate suspended from the ceiling near an electric light in order not to interfere with the normal activities in tobacco warehouses, and so that it may be operated from a double socket without incurring extra cost for wiring. The motor must operate continuously in order to prevent the escape of the insects that are trapped.

In experiment No. 1 (Table 1) the insects were collected from the traps twice each week, and in experiment No. 2 (Table 2) weekly collections

were made. It was concluded that the weekly interval is most satisfactory, since a one-pint jar attached to the trap will accommodate a catch of approximately 150,000 cigarette beetles, this number being much larger than the average weekly catch.

No definite conclusions were reached concerning the intensity of the light most satisfactory for use with the trap. Electric light bulbs of 15 watt, 40 watt, 60 watt, and 75 watt capacity were used in these experiments, and large catches of insects were made with each of these bulbs. When a light bulb of 100 watt capacity was used the light appeared to repel the beetles, and it was concluded that lights of this degree of intensity should not be used. Further experiments will be conducted with lights of different intensities and with colored lights in order further to test the reactions of the beetles.

DATA ON TRAPPING EXPERIMENTS.—Experiments with the suction light trap were conducted during August, September, October, and November, 1932, in tobacco warehouses of the bright tobacco belt. Traps were operated in both open and closed tobacco storages. The open storage type of warehouse is constructed of sheet metal walls, containing large openings which give practically outside conditions of temperature, while the closed storage is usually a brick or concrete building containing doors, windows, and ventilators in the walls.

EXPERIMENT NO. 1.—In this experiment from 7 to 14 traps were operated in open storage tobacco warehouses, containing approximately 2,500,000 cubic feet of storage space. The results of the trapping for the period August 11 to November 10 are given in Table 1.

The beetles were killed in the laboratory with chloroform and sifted through a 14-mesh screen, which allowed the cigarette beetles to pass through but retained practically all moths, miscellaneous insects, and trash. The number of beetles in each catch was determined by placing them in a glass graduate which had been calibrated by counting several lots of 1,500 and measuring the space occupied by them. This method of determining the numbers caught was found to be more accurate than weighing the insects, and more expedient than counting each lot.

The largest catches (Table 1) were made during the period August 25 to September 6, when the mean temperature was high. The beetles were largely inactive at mean temperatures below 65°F., and it is interesting to note the great reduction in the catches during the cool weather occurring after September 6. The increased humidity caused by rainy days appeared to have little effect on the activity of the beetles.

EXPERIMENT NO. 2.—From September 19 to November 5 another experiment was conducted in a closed storage tobacco warehouse, con-

TABLE 1. CIGARETTE BEETLE ADULTS CAUGHT WITH THE SUCTION LIGHT TRAP IN OPEN STORAGE TOBACCO WAREHOUSES CONTAINING APPROXIMATELY 2,500,000 CUBIC FEET, OF STORAGE SPACE AUGUST 11 TO NOVEMBER 10, 1932

Date insects collected (1932)	Interval Days	Number of traps	Cigarette beetle adults Total	Cigarette beetle adults Average per trap	Temperature Aver. Max. °F.	Temperature Aver. Min. °F.	Temperature Mean °F.	Mean relative humidity Per cent
Aug. 15.....	4	7	215,800	30,829	87	67	77	53
18.....	3	12	679,600	56,633	92	65	79	57
23.....	5	9	435,200	48,356	83	65	72	64
25.....	2	11	468,000	42,545	88	62	75	57
29.....	4	10	985,800	98,580	93	65	79	57
Sept. 1.....	3	14	1,270,100	90,721	100	73	87	56
6.....	5	13	875,500	67,346	96	72	84	67
8.....	2	9	30,100	3,345	83	64	73	57
12.....	4	13	69,900	5,377	80	57	69	50
15.....	3	8	51,900	6,487	84	57	70	63
19.....	4	12	65,000	5,417	84	60	72	59
22.....	3	11	62,900	5,718	86	62	74	68
26.....	4	11	55,900	5,082	81	61	71	64
29.....	3	11	17,100	1,555	73	59	64	78
Oct. 4.....	5	11	33,000	3,000	77	49	63	53
6.....	2	10	37,200	3,720	78	63	71	91
10.....	4	10	2,000	200	72	43	58	66
13.....	3	10	7,400	740	70	48	58	61
17.....	4	10	300	30	69	47	58	73
20.....	3	10	14,400	1,440	71	63	67	93
24.....	4	10	4,500	450	72	49	60	68
27.....	3	10	11,800	1,180	72	57	64	88
31.....	4	10	3,400	340	65	43	54	62
Nov. 3.....	3	10	40	4	60	39	49	68
7.....	4	10	24	2	62	45	53	79
10.....	3	10	200	20	61	54	57	96
			5,397,064					

taining 3,125,000 cubic feet of space. The results secured from the operation of 5 to 22 traps are given in Table 2.

TABLE 2. CIGARETTE BEETLE ADULTS CAUGHT WITH THE SUCTION LIGHT TRAPS IN A CLOSED STORAGE TOBACCO WAREHOUSE CONTAINING 3,125,000 CUBIC FEET OF STORAGE SPACE, SEPTEMBER 23 TO NOVEMBER 5, 1932

Date insects collected (1932)	Interval Days	Number of traps	Cigarette beetle adults Total	Cigarette beetle adults Average per trap	Temperature Average Max. °F.	Temperature Average Min. °F.	Temperature Mean °F.
Sept. 30.....	7	21	1,155,100	55,005	71	57	64
Oct. 6.....	6	22	1,627,700	73,986	76	52	64
14.....	8	15	579,100	38,607	69	44	56
21.....	7	16	341,700	21,356	72	55	63
29.....	8	5	196,500	39,300	70	47	58
Nov. 5.....	7	11	8,900	809	62	39	51
Total.....			3,909,000				

The largest average catch (Table 2) was made during the interval September 30 to October 6, when 22 traps caught an average of 73,986 beetles each. As in experiment No. 1, the temperature appeared to be

the controlling factor in the activity of the beetles, although data on the relative humidity were not available.

The temperature records given in Tables 1 and 2 were obtained through the cooperation of the U. S. Weather Bureau.

It is apparent that these large catches will serve materially to reduce the population of cigarette beetles in tobacco warehouses; further experimentation is necessary, however, before the trap can be recommended as a control measure. No reliable method has been devised to determine the insect population of an infested storage, and therefore no statements can be made concerning the degree of control obtained from the large catches of cigarette beetles shown in Tables 1 and 2. In Table 1 the decline in the catches made after September 6 might indicate that most of the beetles in these warehouses were captured by the traps. This conclusion should not be drawn, since the traps were not operated in the warehouses throughout the active season of the cigarette beetle (May to November).

The data in Tables 1 and 2 are presented to indicate the possibilities of the trap, and this paper is intended as a progress report on trapping experiments. Fumigation is more effective than trapping when cured tobacco is stored in fumigable warehouses, but much tobacco is stored, during the aging process, in open storage warehouses which cannot be fumigated. It is in this type of tobacco warehouse that trapping will be most useful in combating the cigarette beetle.

A HYMENOPTEROUS PARASITE (*CEPHALONOMIA GALLICOLA* ASHM.) NEW TO THE CIGARETTE BEETLE (*LASIODERMA SERRICORNE* FAB.)[1]

By C. W. KEARNS,[2] *University of Illinois*

The presence of this parasite in tobacco storages infested with the cigarette beetle has not to the knowledge of the writer ever been noted. This parasite was first found by the writer in October 1933 at the University of Illinois in a culture of the cigarette beetle which originally came from the U. S. Bureau of Entomology, Laboratory of Stored Tobacco Insect Investigations at Richmond, Virginia. The fact that

[1]Contribution from the Entomological Laboratories of the University of Illinois, No. 163.

[2]The writer wishes to acknowledge his appreciation for the many helpful suggestions of Dr. C. L. Metcalf of the University of Illinois. He is also indebted to Mr. C. F. W. Muesebeck for his valuable assistance in the identification of specimens and his opinion regarding a possible case of synonomy.

its presence had not previously been noted by workers in this laboratory might indicate that the parasite entered the culture from some source of infestation about the Entomological Laboratory of the University of Illinois. In as much as the parasite displays some qualities which might prove to be of use in the control of the cigarette beetle, this preliminary report on its biology is presented.

This particular species, *Cephalonomia gallicola* was described by Ashmead in 1887, and the author has been unable to find any literature concerning this species since that date. However, Mr. C. F. W. Muesebeck of the U. S. Bureau of Entomology is of the opinion that *Cephalonomia quadridentata* Duchaussoy (1917) will prove identical to *Cephalonomia gallicola*. Van Emden (1931) published an excellent account of the Morphology and Ecology of *quadridentata* in which he attempts to distinguish between *quadridentata* and *gallicola*. By comparing the author's specimens with Van Emden's figures and morphological discussion, the author is led to believe, as Mr. Muesebeck, that the two are identical. Aside from the work of Van Emden only scattered notes on species of this genus are to be found in the literature. Credit for the first observation on the habit and mode of parasitism of any member of this genus should probably be given to Captain Xambeu (1894) who recorded a short description of the parasitic habit of *Cephalonomia xambeui* Giard (1898) on *Ptinus irroratus* Kiesw.

The following data were gathered from material kept in a room in which the temperature varied from 20°C. to 26°C. with a daily mean temperature of 23.5°C. The ensuing discussion is based upon the accounts of eleven specimens which have been studied in their transformation from egg through adult life.

Egg.—The eggs are crystalline white, elliptical in shape, 0.82 mm. in length and 0.66 mm. in width at the point of their greatest dimension. They are laid upon either mature larvae, prepupae, or pupae of the beetle. If the larval or prepupal stage is the chosen host, the eggs are laid transversely upon its ventral surface in the soft intersegmental tissue between the prothoracic sternite and the terminal abdominal segment, whereas, if the pupal stage is chosen, the eggs are laid transversely upon the dorsal surface of the abdomen in the soft intersegmental tissue. The eggs are not forced beneath the skin but are merely attached to the surface by a fluid emitted from the female while laying. In some cases the female will break the skin of the host by chewing a particular area where she later lays an egg. This action probably assures her progeny of immediate access to food upon hatching as well as fur-

nishes her a supply of nourishment. A single host may bear from 1 to 9 parasite eggs which usually hatch within 2 to 4 days after being laid.

LARVA.—(Fig. 0, 3, 5). The larvae of the parasite upon hatching are white, slightly transparent, and without any evidence of segmentation or a very definite form. They immediately begin feeding upon the host through punctures made in the body wall of the latter by the mother previous to laying or by breaking the skin of the host with their own rudimentary mouth parts. The feeding process is usually completed within 2 to 3 days time after hatching, during which time the larvae assume a lemon yellow color and exhibit near the end of their feeding period a definite segmentation and pyriform shape. After completing their feeding period, the larvae construct silken cocoons, usually within the next twenty-four hours, inside the cocoon of their host, and here they remain quiet from 3 to 5 days. The length of larval life then appears to vary from 6 to 9 days under the conditions in which these parasites were reared.

PUPA.—The pupal stage varies in duration according to the sex and particular form of the adult in the process of development. The female requires a period from 11 to 18 days; the winged males, 9 to 15 days, and the wingless males, 7 to 12 days.

ADULT.—There are three distinct adult forms to be found in this species, the males being dimorphic. The females (Fig. 77, 4) are wingless, 2 mm. to 3 mm. in length, yellowish-brown in color, and possess three minute ocelli. The wingless males (Fig. 77, 1) are 1.5 mm. to 2 mm. in length and slightly paler in color than the female. They possess three well developed ocelli, and a dark transverse band upon the caudal half of each visible abdominal segment. The winged males (Fig. 77, 2) are 1.3 mm. to 2 mm. in length and possess all the other characteristics of the wingless males, differing only slightly in the shape of the head and compound eyes.

The completely developed adults remain in their cocoons from 1 to 3 days after their emergence from the pupal stage. Ordinarily both males and females develop upon the same host individual and spin cocoons adjoining one another. Since the males develop before the females, they are often found to chew their way into the cocoons of their sisters and mate with them before the latter have emerged from their cocoons. However, fertilization of the eggs is not necessary to insure the production of offspring, as the female may reproduce parthenogenetically, exhibiting the phenomena of arrhenotoky. After emergence from their cocoons, the females crawl about searching for suitable host material upon which to feed or lay eggs. They invariably choose hosts inclosed

in cocoons and in the mature larval, prepupal, or pupal stages. The female wasp enters the host's cocoon by chewing a small hole in its wall. Here she may remain for a period varying from a few hours to two days feeding and laying eggs.

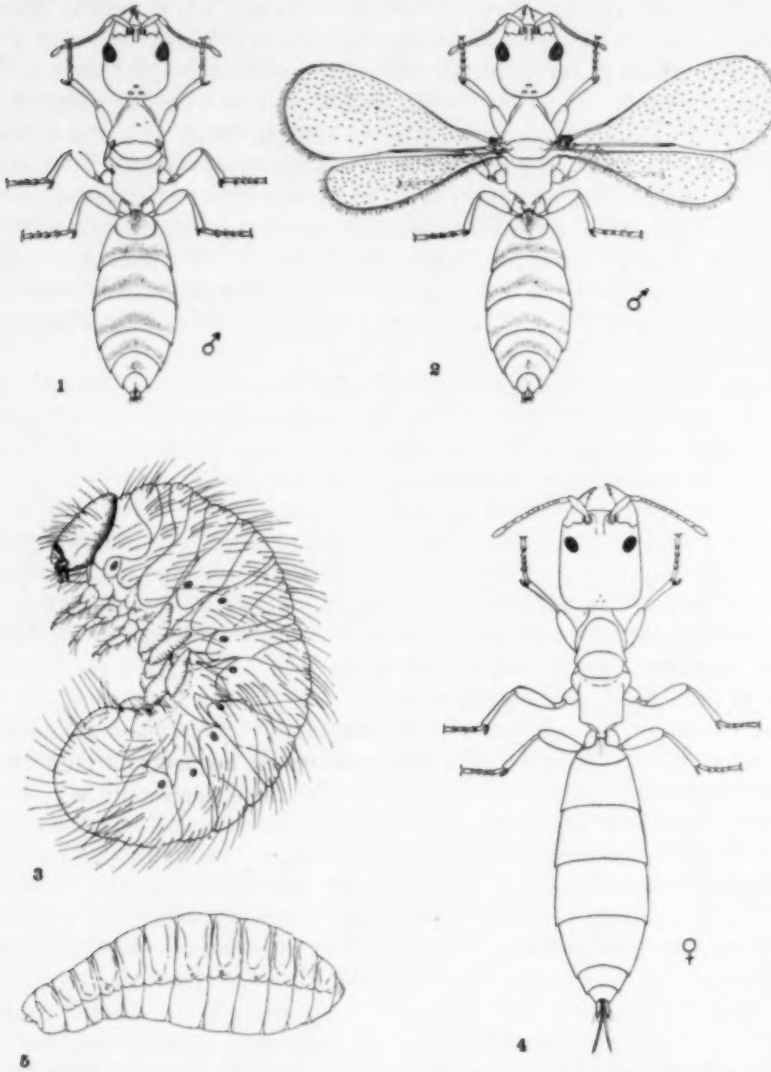

Fig. 77.—1 Wingless male parasite, 2 winged male parasite, 3 larvae of parasite feeding upon larva of cigarette bettle, 4 female parasite and 5 mature larva of parasite.

A single freshly emerged female wasp was found to parasitize 76 individual hosts over a period of 36 days. In addition to the number of hosts actually dead from parasitism, 42 others were found to have died from other means. These additional dead were then cleared in a solution of 10 per cent potassium hydroxide and examined for evidence of feeding punctures by the wasp. Out of the latter number, 21 were found to show definite perforations in the body wall similar to those identified as feeding punctures on other specimens which were known to have died as a result of the feeding habits of the wasp alone. This particular wasp deposited 158 eggs averaging 2.2 eggs per host.

Important Factors Influencing Use in Biological Control

1. The characteristic habit of parthenogenetic reproduction gives assurance that each female will produce the desired parasitism whether or not she has been previously fertilized by the male.
2. The habit of the adult female feeding upon the host is fatal to the host as well as the work of the larvae.
3. From 1 to 9 parasites may be developed upon a single host, thus multiparasitism does not result in the loss of progeny.
4. The number of eggs laid upon a single host appears to be correlated to a certain extent with the abundance of host material. A scarcity of the host seems to encourage the female to lay a greater number of eggs per individual host and often to return to the host upon which she has previously oviposited and lay additional eggs.
5. The effect of feeding of a single parasite larva is sufficient to cause the death of the host.
6. The adults do not exhibit any tendency to be either positively or negatively phototropic, and, therefore, would not suffer a reduction in their number by being attracted to light traps commonly in use in tobacco storages.
7. The parasite can maintain itself under adverse climatic conditions to at least an extent equal to that of its host.[3]
8. The slender body form and wingless condition of the female permit it to enter tiny cracks and crevices and to penetrate deeply into tightly packed tobacco.

[3]This statement is based wholly upon the observation of cultures exposed to adverse conditions of temperature and humidity which were sufficient to cause the death of many of the beetles in the cultures without any visible affect upon the adult parasite. The pupae of the parasites in such cultures completed their normal development as did the mature larvae which did not require additional food.

CONCLUSION.—Although the writer has not yet had the opportunity of making the detailed study necessary to give a fairly accurate estimate of the value of this parasite, certain facts already indicate, with a fair degree of certainty, that over a period of time a great deal of benefit could be derived from its use. It is apparent that this species could not be expected to produce its effect as soon as other hymenopterous parasites such as *Trichogramma* and *Habrobracon* are expected to do in the case of other biological control problems. However, this handicap would probably be considerably offset by the fact that *Cephalonomia gallicola* is hardier and would be used in situations where it is more or less sheltered from adverse climatic conditions which would permit it a longer yearly period in which to reproduce. *Cephalonomia gallicola* appears to have a distinct advantage over the species of hymenopterous parasites normally found in tobacco storages such as *Aplastomorpha vandinei* Tucker and *A. pratti* Crawford which are winged and strongly attracted to light traps where they die with the trapped hosts. In as much as there are a great many open type storages in the tobacco industry which cannot possibly be fumigated, it seems that this parasite could be introduced and used along with light traps as one of the few possible means of reducing an infestation under such conditions.

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THE CLOVER ROOT CURCULIO (*SITONA HISPIDULA* FAB.) IN KANSAS[1]

By GEO. EDWARD MARSHALL, *Assistant Entomologist,*[2] *Indiana Agricultural Experiment Station* and DONALD A. WILBUR, *Assistant Professor of Entomology Kansas State College*

With the steady decline in the alfalfa acreage in Kansas from 1,243,486 acres in 1919 to 640,299 acres in 1930, there has been a steady increase in the kinds and numbers of insects affecting alfalfa. Several of the most abundant and injurious insect enemies of alfalfa in Kansas were not important factors prior to 1919 when alfalfa growing was near its peak. Among those now known to be present is the clover root curculio, *Sitona hispidula* (Fab.) which was not discovered in Kansas until 1923. Because of its insidious methods in attacking the alfalfa plant, many growers even yet are unaware of the presence of this pest in their fields though there may be millions of the insects present.

The beetles were first taken in Kansas by Dr. R. C. Smith of the Kansas Agricultural Experiment Station. He found them at Manhattan in large numbers on lawns having a white clover mixture. He discovered that much white clover sod was being destroyed by this curculio with the help of the clover root borer and the clover leaf weevil. Though many adults were taken in white clover patches, only an occasional specimen could be found in alfalfa. During the next few years, however, the population in alfalfa increased to such an amazing extent and the injury became so marked that a study was begun in 1928 of the Curculionidae affecting alfalfa, with special attention given to the clover root curculio.

HOST PLANTS AND INJURY.—Various authors have listed red and white clover, alfalfa, and blue grass as host plants of both larvae and adults in North America. In Kansas the known hosts are white clover, alfalfa and sweet clover, and the injury is much the same on all three plant species.

There are several reasons why the clover root curculio is considered to be especially dangerous to Kansas alfalfa and sweet clover:

1. The larvae cut off the fine feeding roots, eat into and destroy the nodules, gouge out and frequently girdle the tap roots from the surface to several inches down.

2. The beetles feed on the leaves throughout the summer and fall.

[1]Contribution No. 414, from the Department of Entomology, Kansas State College.

[2]The work by Mr. Marshall was in preparation for a thesis in partial fulfilment of the Master's degree at Kansas State College.

3. The gouges made by the larvae on the tap roots occur at a time of year in Kansas when the soil is warm and moist. This condition offers an excellent opportunity for infection of alfalfa by such diseases as bacterial wilt.

4. In all stages this insect is so small that it is rarely found by the grower and if found, it is not correlated with the injury, though over a million individuals per acre may be present.

5. The damage done to alfalfa, while not ordinarily conspicuous at any one time, extends over the entire growing season.

6. In Kansas the number of clover root curculios have increased greatly during the past five years.

7. Fungous and bacterial diseases, insect parasites and predators of the clover root curculio have been comparatively scarce in Kansas up to the present time.

LIFE HISTORY AND HABITS.—A summary of the length of the stages as determined by various workers is as follows:

	Days Egg stage	Days Larval stage	Days Pupal stage	Days Egg to adult
Wildermuth (4)	13	17–22	8–10	38–43
Bigger (1)	15–18	22–26	17–22	———
Marshall and Wilbur	6–9	45–49	8–16	59–74
Jackson (2) (England)	25 to 7 months	56–112	28	

Egg.—Females were observed to oviposit under field conditions at Manhattan, Kansas, during April, May, June, July, September, October, and November. Thus it appears that oviposition occurs whenever the weather is not too cool in the fall and spring nor too hot in summer. The number of eggs laid by different individuals varies greatly. One caged female laid 37 eggs in two days, the highest previously recorded being 12 in one day. Bigger (1) found an average of 167 eggs per female deposited at the rate of two a day.

According to Webster (3) there are two generations a year in the warmer climates of the area in which the clover root curculios are found. This does not appear to hold true for Kansas. There is a rather heavy egg deposition in the fall, but what happens to the eggs is not known. It is assumed that the eggs overwinter before hatching, as is the case in England (2). The length of the egg stage in mild weather is very short, averaging from six to nine days.

Larva.—Upon hatching, the larva begins to crawl very rapidly. If it has emerged from an egg on a leaf, it crawls until it falls to the ground. Crawling is again resumed in search of a crack in the soil which will afford protection from the sun and provide an entrance to tender roots. At no time were first instar larvae observed digging into the soil. Rather,

they found a crack and followed it down until they came upon a root or nodule. In several cases the larvae began feeding on nodules or roots within twenty minutes after they entered the soil.

The activity of the larvae about the roots in the soil was observed by means of a cage consisting of a young alfalfa or white clover plant placed in finely sifted soil between clear glass plates. A small band of blotting paper was fastened around the edges to hold the soil and to absorb moisture. The plates were held together by means of heavy rubber bands. All movements, developmental stages and effects on the host plant could be closely watched through this cage.

Second instar and older larvae may do much burrowing in the soil. The larva will first loosen the soil by digging with the mandibles either open or closed. The head is extended against the front of the tunnel and then brought forward and downward. In this manner the soil which has been loosened is carried beneath the abdomen. The body of the larva just posterior to the head is then much enlarged, more noticeably on the ventral side, and by muscular contractions this enlargement passes back almost to the tip of the abdomen in a wave-like movement. By this movement the loosened earth is moved backward. After this the tip of the abdomen is contracted until the loosened soil is behind it, then the abdomen is extended. This presses the soil backward in the tunnel and pushes the larva forward. By turning from side to side, the larva is able to burrow in a straight line, although normally it assumes a somewhat curved position. Four or five inches of straight burrows are frequently found.

Activity of Larvae on Roots.—When a larva makes contact with a small feeding root, it soon consumes the root and starts searching for another. Often the larger fibrous roots are detached in which case the loose section is left alone. It is evident that if the larval population on a given plant is large, the loss of these surface feeding roots must be serious to the plant. The ideal feeding grounds for the younger larvae are in the nodules. A larva may feed within a large nodule for three or four days, until nothing but the outer shell of the nodule remains. The general movement of the larvae as they develop in size is toward the larger roots and finally as they attain full growth there is quite a concentration around the tap root. This accounts for the girdled and scarred condition of this part of the plant.

Number of Larvae.—During the latter half of May and the first half of June, enormous numbers of fourth and fifth instar larvae may be found in certain alfalfa fields. While examining a field of alfalfa near Marysville, Kansas, in which the chief interest was the destruction

of the first cutting by the clover leaf weevil, a count was taken of the clover root curculio population. The results are as follows:

	Larvae per unit	Larvae per acre
Larvae per alfalfa plant, 6 inches deep.....	5.4	———
Larvae per square foot, 6 inches deep.....	25.6	1,115,136

Bigger (1) made counts of much greater populations in Illinois.

Figure 78, number 1 shows the work of an older larva on a large root of a young alfalfa plant. The larva is in about the center of the hole left after it has consumed a root for a considerable distance. The white masses mixed with the darker soil particles are defecations.

Figure 78, number 2 shows clearly the damage by Sitona larvae to three year old alfalfa roots. The greatest depth of feeding recorded in the literature is five inches, but injury has been found in Kansas as deep as eight inches below the ground. Root B of Figure 78 shows typical long grooved feeding, while root A shows the circular gouges as well as many short grooves which girdle the structure. It may be observed that the most extensive feeding is near the crown which makes possible a favorable entrance for such plant diseases as crown rot. In some instances, larvae burrow into the tap root for a short distance up to half an inch, thus resembling the clover root-borer, *Hylastinus obscurus* (Marsh.).

The question was raised as to how much water larvae can stand without drowning, because they are so frequently subjected to heavy spring rains in Kansas. Thirty-four hours were required to kill them by soaking in a cup of tap water.

Pupa.—The pupal cell is an oval, earthen cell usually found within three inches of the surface. The larva shapes the cell by turning its body and by using its mandibles. When the cell is shaped, a liquid is added from the mouth to the soil which aids in preventing the soil from crumbling. Two or three days are required for the construction of such a cell. The construction of the cell and the activity of the pupa within the cell may be readily observed by placing mature larvae in the glass cages previously discussed.

The majority of the larvae pupate at about the same time. During 1928 and 1929, holes were dug in alfalfa fields and the larvae and pupae counted. Eight diggings were made between May 31 and July 2. In both years the largest number of pupae were found between June 7 and June 25 though a few pupae occurred after July 15.

The pupal period varies from eight to sixteen days, with the average being about ten days. Pupae reared at room temperatures in December required seventeen to nineteen days, while those reared in glass cages at room temperatures during June required ten to seventeen days. Near

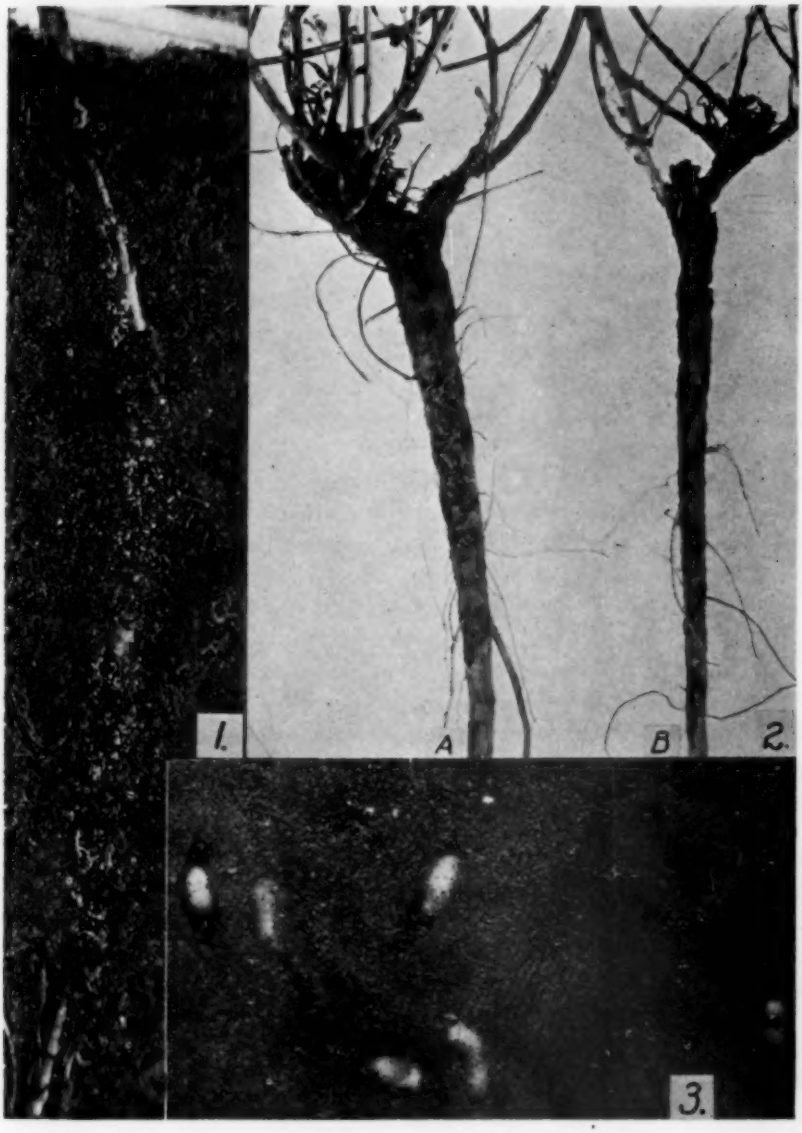

Fig. 78.—1, Larva feeding on a large root of young alfalfa plant. In glass cage; 2, Two specimens of three year alfalfa roots showing types and extent of larval feeding; 3, Larval cells. In glass cage.

the end of the pupal period the eyes turn a reddish brown. Soon the snout darkens somewhat and the wings expand and assume the natural position in the adult. At this stage the entire body begins to turn brown. Another day is spent in the cell after which the new adult begins to burrow toward the surface.

Adults.—In Kansas the majority of adults emerge by June 25. A few days after emergence they begin to feed and continue until cold weather. They do not appear to aestivate even during the hottest Kansas summers. During the hot days they will feed through the night and up to about ten o'clock in the morning in the upper region of the alfalfa plant, and will move down during the extreme heat of the day. They are weak fliers.

The feeding injury by the adults to alfalfa and clover has been pictured by Wildermuth, Bigger, and others. The same type and degree of injury occurs in Kansas that has been found elsewhere. The most distinguishing feature is the crescent shaped notches in the leaf margins.

In Figure 79 clover root curculio feeding may be observed in comparison with that of two other curculios, the clover leaf weevil, *Hypera punctata* (Fab.) and the imbricated snout beetle, *Epicaerus imbricatus* Say, all present in alfalfa in Kansas.

Plant 1 may be readily distinguished as the host to the clover root curculio by the crescent notches throughout the plant. Feeding has been concentrated somewhat, however, on the lower protected branches. Plant 2 has been nearly stripped of leaves by the clover leaf weavil. Even the midribs in some instances were consumed. These insects start their work on a plant with the lower leaves, hence the growing tip is the last to be destroyed. Imbricated snout beetle injury, as evidenced in plant 3, is more generally distributed throughout the plant, as these insects make no special attempt to feed under cover. The leaf margins appear ragged and frayed due to the habit of these beetles to tear off the leaf with their mandibles rather than by cutting or biting. These curculios, more often than the others mentioned, destroy the terminal buds.

The adults copulate during the fall. Two adults were observed in copulation from 9:15 a. m. until 12:00 n., with intermittent intervals of detachment. Eggs were laid within 12 hours after copulation. Many eggs were laid during the warm days of September and October.

The beetles have been taken at various times throughout the winter hibernating beneath the debris in the alfalfa field, though all attempts to get them to hibernate in cages failed. Bigger (1) reports that adults submerged in water for 12 hours survived, as did those which had been frozen in solid blocks of ice.

Fig. 79.—1, Feeding injury to alfalfa by adult of clover root curculio, *Sitona hispidula* Fab.; 2, Same by adult of clover leaf weevil, *Hypera punctata* (Fab.); 3, Same by adult of imbricated snout beetle, *Epicaerus imbricatus* Say.

Great numbers of adults were collected during the summer by spreading a rug or carpet over the white clover in a lawn at dusk and examining the underside of the rug at frequent intervals after dark.

No insect parasites nor predators were discovered in the observations at Manhattan. However, during late May of 1928 it was found that about one larva in six taken from diggings in alfalfa fields was diseased. The larva became distended, light brown in color, and later dried up. Diseased specimens were sent to Dr. G. F. White of the Bureau of Entomology for identification, who reported that nematodes of the genus Diplogaster were the cause of death.

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PUPAL PARASITES OF THE ORIENTAL FRUIT MOTH[1] IN SOUTH CAROLINA—A PRELIMINARY REPORT[2]

By W. C. Nettles

Entomologists in various parts of the eastern United States have devoted considerable effort during the past few years to a study of the parasites of the Oriental fruit moth. Most of the emphasis has been placed on larval parasitism and to a smaller extent on egg parasitism while pupal parasitism has received but scant consideration. When the study of pupal parasites was begun during July, 1930, the records of pupal parasitism were few and pupal parasitism was considered unimportant.

References to five species of pupal parasites of the Oriental fruit moth have been located in the literature by the writer which are considered of natural occurrence in the eastern part of the United States. *Centeterus ineptifrons* Gahan was reported by Stearns (4) from Virginia and by McConnell (3) from Maryland. *Ephialtes aequalis* (Prov.) was also

[1] *Grapholitha molesta* Busck; Order, Lepidoptera; family, Olethreutidae.

[2] Technical contribution No. 29 (New series) of the South Carolina Experiment Station.

reported by Stearns (4) from Virginia and by McConnell from Maryland. *Itoplectris conquisitor* Say was reported by Stearns from New Jersey, Pennsylvania, and Virginia. *Miotropis clisiocampae* Ashm. and *Syntomosphyrum esurus* Riley were reported by Driggers (1) from New Jersey.

Six additional species of parasites were reared from Oriental fruimoth pupae during 1930 and reported as such in South Carolina Ext periment Station Bulletin 278 (2). The list follows:

1. *Arachnophaga* new species.
2. *Arachnophaga* new species (not same as above).
3. *Brachymeria hammari* (?)
4. *Eupelmus cyaniceps* var. *amicus*.
5. *Eupelmus limneria*.
6. *Haltichella longicornis*.

Work was resumed on the pupal parasites during 1932 and emphasis was placed on the following points:

1. Extent of pupal parasitism.
2. Relative importance of species.
3. Biology of the most important species.

EXTENT OF PUPAL PARASITISM.—Limited data indicate that pupal parasitism is of more importance than indicated by investigators in other sections and is of significant proportions in South Carolina. Parasitism of pupae collected from July 22 until September 16 was 56 per cent based on the fact that 58 parasites and 46 moths emerged from pupae. Numerous pupae were collected at the same time from which emergence did not take place. Pupae were collected from their cocoons on peaches and on spurs from which peaches had been picked. They were then placed in individual vials and kept in the insectary until emergence took place. Parasites were also reared from pupae located in cocoons spun under bands, and from pupae exposed in corrugated paper, but they are not considered in this report.

RELATIVE IMPORTANCE OF SPECIES.—Parasites were reared from pupae collected from under bands and from peaches at time of harvest. Seventy-three specimens were reared from pupae collected in the above described situations and distributed among the several species as listed.

BIOLOGY OF THE MOST IMPORTANT SPECIES.—From the tabulated information in the following section it will be noted that *Haltichella longicornis* and *Brachymeria hammari* were the species most frequently encountered, as approximately three-fifths of the total parasitism was attributed to them. These two little known insects, therefore, were chosen for study.

Species	Number specimens	Per cent of total
Haltichella longicornis Ashm.	28	38.3
Brachymeria hammari Cwfd.	16	21.9
Brachymeria ovata Say	7	9.6
Eupelmus limneria How.	5	6.8
Encyrtaspis semirufus Gahan	5	6.8
Spilochalcis delira (Cress)	5	6.8
Anastatus sp.	2	2.8
Ephialtes aequalis (Prov.)	2	2.8
Eupelmus amicus Ashm.	1	1.4
Eurytoma tylodermatis Ashm.	1	1.4
Arachnophaga sp.	1	1.4

Both *Haltichella longicornis* and *Brachymeria hammari* have life histories that are similar in many respects. Both species were able to parasitize insectary-reared pupae and to emerge after a total developmental period of 15 to 18 days during the last of July and the first of August.

Whether *Haltichella longicornis* and *Brachymeria hammari* always act as primary parasites remains to be seen. In the case of some of the other species the question of hyperparasitism might well be raised on account of the affinities of near relatives.

Haltichella longicornis and *Brachymeria hammari*, in common with many other pupal parasites, possess extremely large hind femora. It is surmised that they serve as claspers by which the female holds pupae for the purpose of oviposition.

Both *Haltichella longicornis* and *Brachymeria hammari* reproduce parthenogenetically, since unmated females were able to produce progeny.

Nineteen adults of *Haltichella longicornis* lived an average of 10.5 days with a maximum 18 and a minimum of three days. Twelve adults of *Brachymeria hammari* lived an average of 7.8 days with a minimum of four and a maximum of 23 days.

Discussion.—In view of the fact that a total of 16 species of parasites have been recorded from the pupal stage of the pest, the conclusion seems justified that it is a stage of the Oriental fruit moth which lends itself to parasitism.

One main factor seems to account for the fact that the pupal stage of the Oriental fruit moth is subject to parasitism. The stage is relatively exposed in comparison with the same stage of other orders and families. All indications are that the pupal stage of Lepidoptera is more susceptible to parasitism than the same stage of other orders.

Acknowledgments.—The writer wishes to acknowledge the criticisms and corrections of the manuscript by Professor Franklin Sher-

man of Clemson College, Dr. Alvah Peterson of the Ohio State University, and Mr. G. H. Aull of the South Carolina Experiment Station.

Preliminary determinations of parasite material were made by Dr. H. W. Allen. Final determinations were made by R. A. Cushman, and C. F. W. Muesebeck of the taxonomic staff of the Bureau of Entomology.

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A NEW DIPPING APPARATUS FOR TREATING CORRUGATED PAPER BANDS FOR USE IN CONTROL OF THE CODLING MOTH

By F. Munger, M. P. Jones and E. H. Siegler, *U. S. Bureau of Entomology*

In dipping corrugated-paper bands that are to be used in codling-moth control, thorough distribution of the chemicals on the paper is accomplished with the minimum of clogging of the tubes by immersing the roll of band material flatwise to one-half its depth at a time. (Fig. 80.) For a 2-inch band the roll should be lowered into the hot solution of beta-naphthol and oil to a distance of 1 inch, removed immediately, and turned upside down as quickly as possible. When the roll has cooled, the untreated half should be similarly dipped, thus making a complete single dip. To make a double-dipped band a second coating is applied in the same manner. Full particulars as to materials, formula, temperature, etc., recommended for the making of bands have been published previously.[1]

The apparatus herein described was used in preparing bands at the Takoma Park, Md., laboratory for the experimental tests conducted

[1]Siegler, E. H., and Munger, F. Preparation and use of chemically treated corrugated bands as a supplemental control for the codling moth. U. S. Dept. Agr. Bur. Ent. Circ. E-294, April 1, 1932.

during the season of 1933 and was found to be thoroughly satisfactory. It is made entirely of metal and should therefore give service over a great many years without further attention. The cost of materials is about $2 and the construction is simple, as will be noted by reference to Figures 81 and 82.

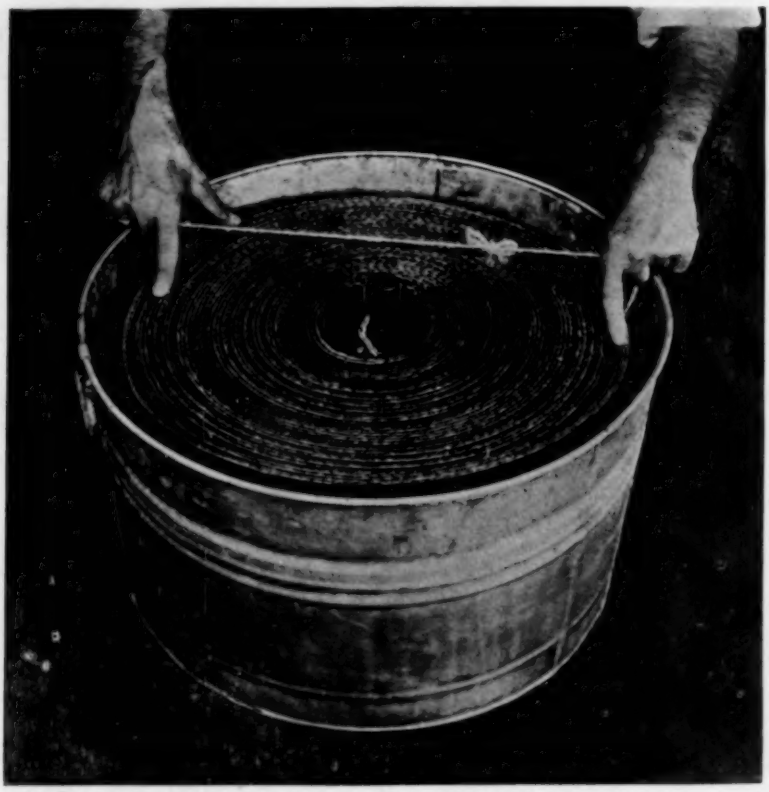

Fig. 80.—Roll of corrugated paper resting on supporting rack of dipping apparatus.

The apparatus described was designed to take care of rolls of corrugated paper 125 feet in length, which can be readily accommodated in a wash tub of 15-gallon capacity. It can, however, be made larger to accommodate rolls of paper containing 250 linear feet, which is the original length as furnished by the paper manufacturers.

The base of the apparatus (Fig. 81) consists of two pieces of flat bar iron, each 17 inches long by 2 inches wide by ¼ inch thick, welded

together at right angles to each other. In order that the base will set firmly on the bottom of the tub, a small bolt and nut (Fig. 81, A) or any other convenient leveling device should be provided.

A wrought-iron bench screw, 1 inch in diameter and 11 inches in length when cut off so that the threaded part is flush with the base, serves for

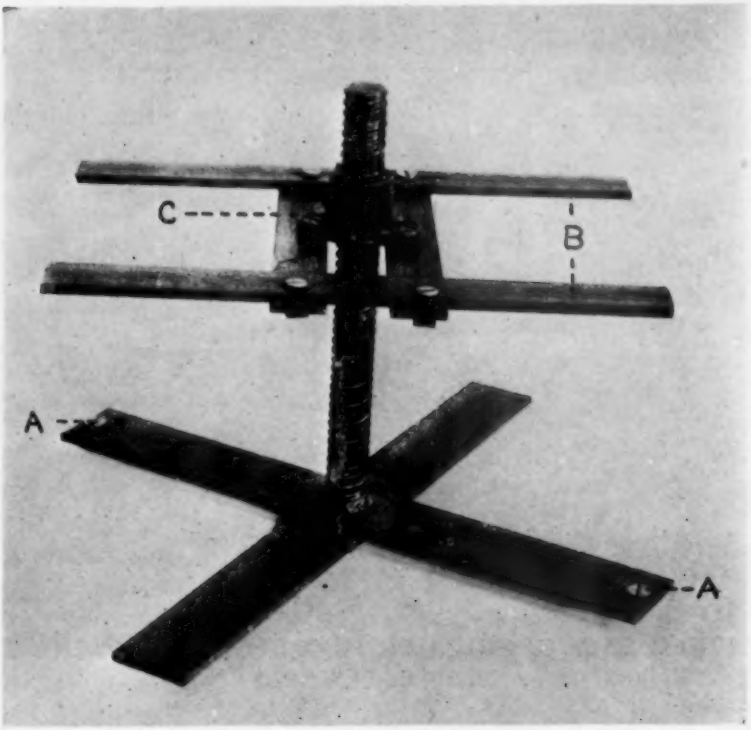

Fig. 81.—Dipping apparatus: A, Leveling screws; B, supporting rack; C, female screw.

raising and lowering the band-support rack (Fig. 81, B), which is attached to the movable female screw (Fig. 81, C). The latter is sold as part of the bench screw.

The band-support rack, a top view of which is shown in Fig. 82, is made of flat bar iron, two pieces being 14 inches long by 1¼ inches wide and ¼ inch thick, and the cross bars of the same width and thickness but 8½ inches long. The rack is held together by four short bolts and is attached to the movable female screw by means of two short bolts.

In using this dipping apparatus, it is only necessary to turn the band-support rack to the proper depth in the chemical solution and proceed with the dipping as suggested in the first part of this paper.

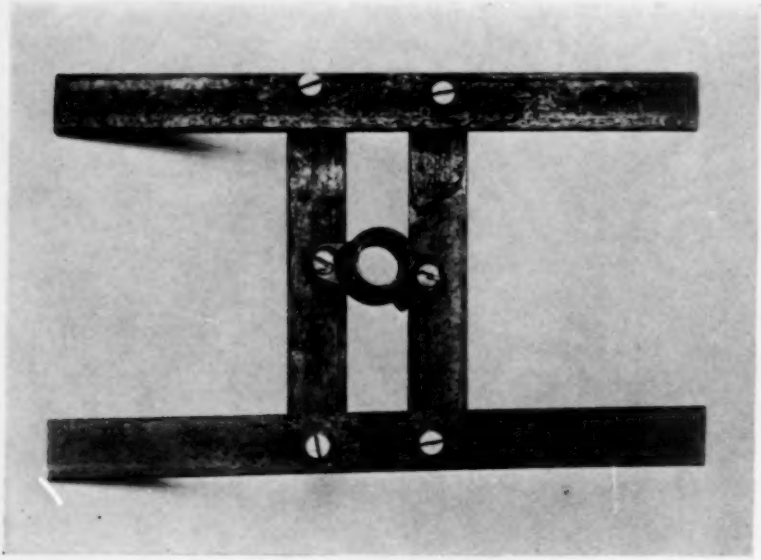

Fig. 82.—Top view of supporting rack.

THE INFLUENCE OF SOIL MOISTURE UPON SURVIVAL OF THE PINK BOLLWORM

By A. J. CHAPMAN, *Junior Entomologist*, and H. S. CAVITT, *Agent, Bureau of Entomology, United States Department of Agriculture, In Cooperation with the Texas Agricultural Experiment Station*

In hibernation experiments at Castolon, Tex., where the winter survival of the pink bollworm (*Pectinophora gossypiella* Saund.) was first studied, it was observed that soil moisture was one of the limiting factors. Since it was impossible to control or evaluate this factor in small-plat field tests, a series of laboratory experiments were conducted at Presidio, Tex., in which the moisture content of the soil containing hibernating long-cycle larvae was controlled. This paper records observations on the effect of different more or less constant soil-moisture percentages in sandy-loam and clay-adobe soils on the survival of the

pink bollworm and upon the rate of emergence of long-cycle moths. The experiments were begun in December, 1929, and concluded in August, 1932, thus covering a period of nearly three years.

INSTALLATION OF INFESTED BOLLS IN CROCKS.—Cotton bolls heavily infested with live long-cycle pink bollworms were buried in 2-gallon earthenware crocks filled with soil of various moisture contents. A crock of this size was large enough to contain a single layer of 25 cotton bolls and sufficient soil for the percentage of moisture to be kept fairly constant. At the bottom of each crock was a ¾-inch hole to allow for drainage and this was covered with a fine-mesh screen to prevent loss of soil. The quantity of soil used in each crock was constant for each soil type and was sufficient to make a layer about 2½ inches deep below the layer of bolls and another of the same depth above and leave 1½ inches at the top to allow for watering.

In the crocks that were given small quantities of water, three small glass tubes were inserted in the soil so that they projected slightly above the rim of the crock and extended down to the layer of bolls. Early in April, or before moth emergence, an 18-mesh screen-wire moth trap was placed over each crock, attached to a crimped galvanized-iron collar that fitted tightly over the top of the crock. The crocks were arranged on shelves in a screened insectary the first and third years and in an adobe shelter the second year.

The first year two 2-gallon crocks, each containing 26 bolls, were used for each test, but in the following two years four 2-gallon crocks, each containing 25 bolls, were used for each test. There were, therefore, 52 bolls per test the first year and 100 per test in each of the other two years. The bolls were collected before frost from cotton fields in the Presidio Valley and those that were the most heavily infested were selected for the tests. From 150 to 300 of these bolls were examined just prior to installation to determine the average number of live long-cycle larvae per boll. By multiplying this number by the number of bolls used per test the approximate total number of larvae used in each experiment was computed. This ranged from 112 the first year to 394 the second year.

Two of the extreme soil types found in the Presidio Valley were used in these experiments, namely, clay-adobe and sandy loam. The soil was taken from the upper 6 inches of the surface in the field. Three samples of each soil type were dried in an electric oven and the average percentage of soil moisture thus determined.

The weight of the soil used in each crock also included the weight of the water in the soil. From the weight of the soil used per crock and

the percentage of water in this soil, it was possible to compute the weight of this volume of soil without the water. Where the desired moisture content in a crock was less than that naturally in the soil, it was necessary to dry out all the soil in that crock and then add sufficient water to bring the water content up to the desired point. Where the desired soil moisture was greater than that naturally in the soil, it was only necessary to add enough water to bring the percentage up to the desired amount. Each crock in the experiments was weighed, as well as the sample of bolls which were to be placed in each crock and the glass tubes and wire screening.

Weighing and Watering.—A figure was obtained for each crock which represented the total weight of the crock, bolls, tubes, wire screening, and soil at the water content being tested. Each crock was weighed at intervals of from two to four days, depending upon evaporation of the water from the soil. The difference between the weight of the crock at such a weighing and the weight when it contained the proper percentage of water represented the loss of water from the soil by evaporation. At each weighing enough water was added to bring the total weight of the crock and its contents up to the desired point. The water was poured through the glass tubes in all crocks except those in which the soil was to be saturated.

Temperature Readings.—To determine the soil temperature at boll depth, thermometers were inserted in certain key crocks in each test. During the first year readings were taken each day at 8 A.M., 12 noon, and 5 P.M., but during the last two years they were taken only at 8 A.M. and 5 P.M. These readings were then averaged to determine a daily mean temperature and a monthly mean temperature in the crocks in each test and for the entire experiment. The temperatures in the different soils varied so little that it was evident that temperature was not a factor in influencing the percentages of survival recorded in the crocks held at the various soil-moisture percentages. It is therefore not further discussed in this paper.

Moth-Emergence Records.—Every morning the moth traps were examined, the moths were removed, and the emergence in each trap was recorded. At various intervals the traps were removed from the crocks and any moths that had failed to enter the traps were recovered and counted. During the period of greatest moth emergence this was done each day.

Records on Soil Moisture.—At the close of the experiment for the last two years, determinations were made to ascertain how closely the soil moisture in the crocks checked with that theoretically obtained

by the frequent additions of water during the experiment. The theoretical and actual soil-moisture percentages varied somewhat (Table 1). Inasmuch as some water in the soil of each crock evaporated between waterings, the theoretical soil-moisture percentage represented the maximum rather than the mean. The average minimum percentage of soil moisture for each crock for the duration of the experiment was therefore obtained and the mean percentage of soil moisture was then computed by averaging the maximum and the mean minimum percentages.

TABLE 1. THEORETICAL AND ACTUAL MEAN SOIL WATER PERCENTAGES IN SANDY-LOAM AND CLAY-ADOBE SOILS, PRESIDIO, TEX., 1930–1931 AND 1931–1932

[The horizontal rules serve to group the percentages, for each type of soil, that have been averaged to get the percentages used in the first column of Table 3.]

Theoretical percentage of soil water	Actual mean percentages of soil water in sandy loam soil		Actual mean percentages of soil water in clay-adobe soil	
	1930–1931	1931–1932	1930–1931	1931–1932
Dry	Dry	Dry	Dry	Dry
5	4.87	4.88	4.93	4.86
8	7.90	—	7.88	—
10	—	9.81	—	9.81
12	11.77	—	11.75	—
15	—	14.78	—	14.88
19	18.67	—	18.76	—
22	—	21.44	—	21.67
24	23.64	—	23.71	—
30	28.79	28.49	—	—
40	—	—	38.01	38.42

EXPERIMENTS OF 1929–1930.—Since the actual soil moistures obtained during 1929–1930 were either far above or below the theoretical mean percentages, which indicated a wide fluctuation in the soil moistures of the crocks, that year's results were not averaged with those of the following 2 years. The percentage of survival as determined by moth emergence for 1929–1930 is shown for both soil types treated in Table 2

TABLE 2. THEORETICAL AND ACTUAL MEAN SOIL-WATER PERCENTAGES AND PERCENTAGES OF SURVIVAL IN SANDY LOAM AND CLAY-ADOBE SOILS, PRESIDIO, TEX., 1929–1930

Percentage of soil moisture			Percentage of survival	
	Actual mean			
Theoretical	Sandy	Adobe	Sandy	Adobe
Dry	—	—	0.89	0.89
5	6.15	10.10	2.68	39.29
12	11.98	15.32	1.79	2.68
19	17.30	20.42	5.36	1.79
26	21.86	24.92	0.00	3.57
33	25.99	28.90	0.00	6.25

together with the maximum or theoretical soil moistures and the actual mean soil moisture percentages tested. Here it is shown that the greatest percentage of survival in sandy soil was 5.36 per cent when the soil moisture content averaged 17.30. No survival was recorded when the

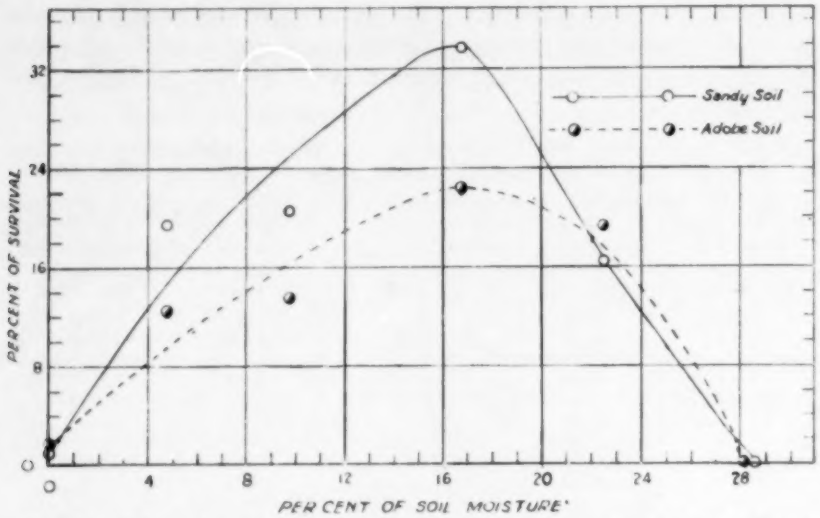

FIG. 83. Effect of percentage of soil moisture upon the survival of the pink bollworm in sandy loam and clay-adobe soils. Presidio, Tex. 1930–31 and 1931–32.

mean soil moisture content averaged 21.86 and 25.99. On the other hand, for adobe soil the maximum survival recorded was 39.29 per cent when the actual mean soil moisture content was 10.10 per cent. Some survival was recorded in clay-adobe soil maintained at the higher percentages of soil moisture but it was observed that some larvae came to the surface of the soil and spun cocoons there. This indicated a possibility that some of these larvae survived and transformed into moths.

RELATION BETWEEN SOIL MOISTURE AND SURVIVAL OF PINK BOLLWORM.—The relationship between the percentage of soil moisture and percentage of pink bollworm survival in sandy and clay-adobe soil for 1930–31 and 1931–32 is shown in Table 3 and Figure 83. Inasmuch as the moisture content of the soil varied from the theoretical points which it was desired to maintain in the crocks, the calculated percentages have been used and the results grouped within about 5 per cent ranges, as indicated by the horizontal rules in Table 1.

In the sandy-loam soil the highest survival over the 2-year period occurred at an average of 16.72 per cent soil moisture. The optimum

TABLE 3. EFFECT OF SOIL MOISTURE UPON SURVIVAL OF THE PINK BOLLWORM AND TIME OF MOTH EMERGENCE, PRESIDIO, TEX., 1930–1931 AND 1931–1932

Average per cent of soil moisture	Per cent of survival 1930–1931	1931–1932	Average	Total moth emergence April	May	June	July	August
				Sandy loam soil				
Dry	2.03	0.38	1.20	0	0	2	6	1
4.87	9.90	29.17	19.53	9	56	14	37	0
9.82	7.23	34.47	20.85	24	98	23	3	0
16.72	11.17	56.82	33.99	39	131	18	6	0
22.54	5.08	27.65	16.36	28	64	1	0	0
28.64	0.00	0.00	0.00	0	0	0	0	0
				Clay-adobe soil				
Dry	2.03	0.76	1.39	0	2	1	7	0
4.89	3.30	21.97	12.63	6	11	10	44	0
9.81	3.30	23.86	13.58	5	43	22	19	0
16.82	5.33	39.77	22.55	30	77	11	8	0
22.69	7.36	32.20	19.78	36	73	2	2	1
38.21	0.00	0.00	0.00	0	0	0	0	0

percentage was placed at 16.72 per cent, obtained by averaging the percentages 18.67 and 14.78 of soil moisture in which the largest number of moths survived during the 2 years.

In the clay-adobe soil the highest survival over the 2-year period

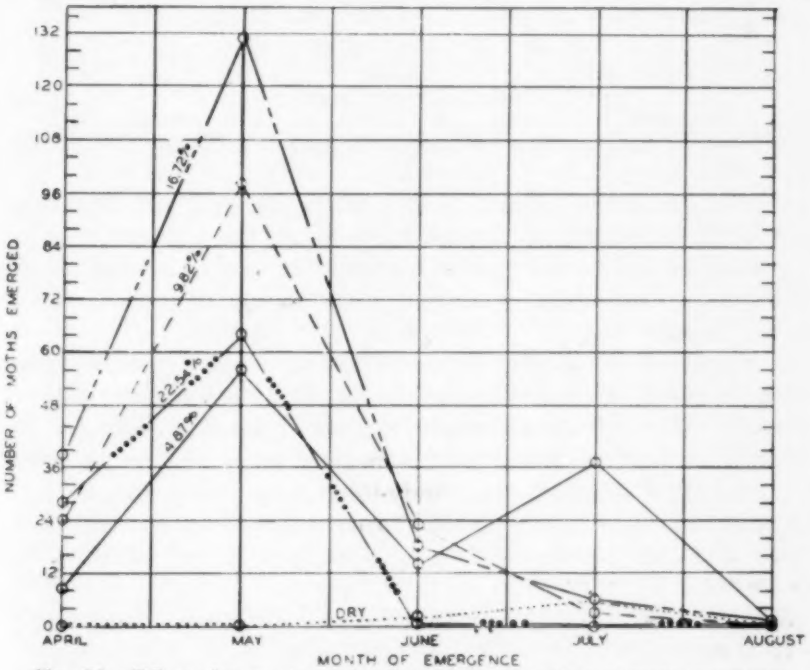

FIG. 84. Effect of percentage of soil moisture upon time of moth emergence in sandy soils. Presidio, Tex. 1930–31 and 1931–32

occurred at an average of 16.82 per cent soil moisture. The optimum percentage is placed at 16.82 per cent, obtained by averaging the percentages 18.76 and 14.88. However, during 1930–31 it will be noted that the highest survival was 7.36 per cent at an average of 22.69 per

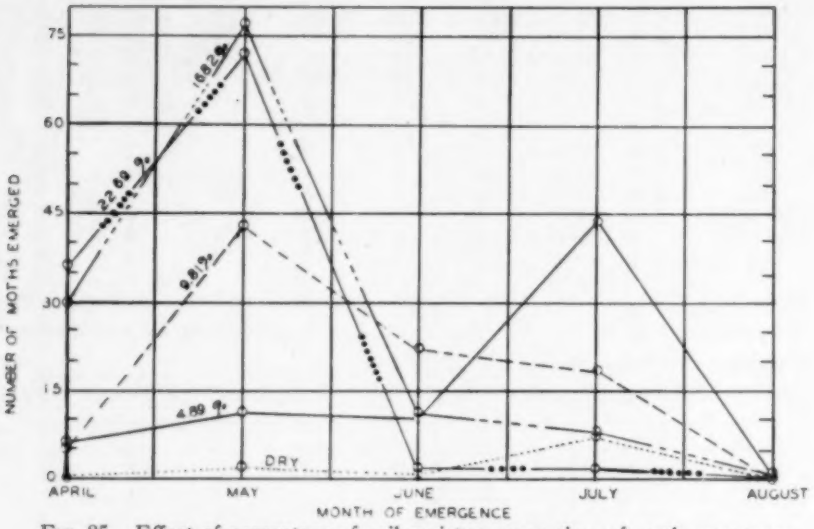

FIG. 85. Effect of percentage of soil moisture upon time of moth emergence in clay-adobe soils. Presidio, Tex., 1930–31 and 1931–32

cent of soil moisture, whereas in 1931–32, it was 39.77 per cent at an average of 16.82 per cent soil moisture. When the numbers of moths that emerged are plotted against the month of emergence (Fig. 85) the lines for the percentages 16.82 and 22.69 are symmetrical and vary within a narrow range.

It will also be noted from Figure 83 that there was a sudden decrease in the survival of pink bollworms in sandy-loam soil when the soil moisture was above the optimum, whereas in the clay-adobe soil the decrease in survival was somewhat more gradual. Clay-adobe soils will hold more moisture than sandy-loam soils and, although moths emerged from adobe soils with higher percentages of moisture than from sandy soils, no insects survived in either type of soil when held at saturation.

RELATION BETWEEN SOIL MOISTURE AND TIME OF MOTH EMERGENCE.—It is shown in Table 3 that the percentage of soil moisture had a decided effect upon the time of moth emergence in both the sandy-loam and clay-adobe soils. These data are plotted in Figures 84 and 85, where

it can be seen that the peak in moth emergence is reached during May from both types of soil regardless of the soil moisture, provided it is above 5 per cent. This is a normal time for the first heavy moth emergence. The peak of moth emergence in the dry soils of both types was reached in July. The sandy soil at 4.87 per cent soil moisture caused a second and somewhat lower peak to occur during July. The peak in emergence from bolls in clay-adobe soil held at 4.89 per cent moisture was reached in July. It appeared that the clay-adobe soil had a tendency to delay moth emergence.

OBSERVATIONS ON THE SUMMER ACTIVITIES OF *APHIS MAIDIS* FITCH*

By HARRY R. BRYSON, *Kansas Agricultural Experiment Station*

The corn leaf aphid, *Aphis maidis* Fitch, is a pest distributed generally over the corn belt of the United States. It is an enemy of corn, sorghums, broom corn, barley and sugar-cane, and its activities would indicate that it is a tropical or a semi-tropical insect.

The first report of the corn leaf aphid in Kansas was made by Popenoe[1] in 1883. McColloch[2] studied the economic importance in relation to the production of corn and sorghums in Kansas. Hayes[3] found that injury to the heads by this insect resulted in the reduction of the germinating power of the seed. McColloch observed also that the insects were found on the sorghums during the early part of the growing season. They transferred their activities to the corn about the time the plants began to form tassels and remained there until the sorghums began to head, when they again were to be found in great numbers in the developing heads. Gui[4] found that the aphids became less numerous when the sorghum plants made their most rapid growth. They were more plentiful but less easily seen about the time the head was ready to emerge from the boot. He also found the aphids well con-

*Contribution No. 411 from the Department of Entomology.

[1]Popenoe, E. A. Report of the Entomologist. 1883. Third Bien. Rept. Kans. St. Bd. pp. 610–617.

[2]McColloch, J. W. The corn leaf aphis (*Aphis maidis* Fitch) in Kansas. 1921. Jour. Econ. Ent. 14:89–94.

[3]Hayes, W. P. Observations on insects attacking sorghums. 1922. Jour. Econ. Ent. 25:349–356.

[4]Gui, Harry L. *Aphis maidis* Fitch, its biology and economic importance. 1926. Master's Thesis. Library, Kansas State College of Agriculture and Applied Science.

cealed within the whorl, feeding upon the tenderest parts of the plant just prior to heading time. Feeding in this protected place, they reproduce rapidly, become extremely numerous some years, and cause severe injury to the florets on the developing head.

Gui observed further that the aphids show a preference for the stems and inner surface of the distal leaf sheaths to other parts of the plant. In some instances the stem is weakened so as to prevent the complete exertion of the head from the boot. This condition resulted in the production of a large number of sterile florets and also encouraged the development of the organisms of molds, rots and fungi.

The writer became interested in the investigations of the seasonal activities of this aphid while conducting researches on the life histories of insects attacking sorghums at Manhattan, Kansas. It is the purpose of this paper to present the results of the investigations of the summer activities of the corn leaf aphid in relation to growing corn and sorghum plants during the seasons of 1931 and 1932.

METHOD.—This study was begun in the summer of 1931, but a more complete investigation was conducted throughout the season of 1932. A series of rows consisting of three varieties of sorghums and two of corn was planted about May 1st, and successive plantings were continued at weekly intervals until the middle of June. The seed was drilled in 50 foot rows, with the three rows of sorghums adjacent to each other in the center of the series, and one row of corn planted on either side of the sorghums.

The corn varieties used were Stowell's Evergreen sweet corn and a dent corn, known as "Pride of Saline," both of which are commonly grown at Manhattan. The sorghum varieties selected included an early maturing one, feterita; a later maturing grain sorghum, and one sweet sorghum, Kansas Orange. Five series were planted adjacent to each other during the season of 1931, while seven series were planted during the summer of 1932.

After the plants in the first two series had attained two inches in height, five plants were selected from each row and the number of aphids counted and recorded. Only two counts were made in 1931, while thirteen were made at weekly intervals during the season of 1932. Notes were taken to show the number of winged individuals present when each count was made. Observations regarding the feeding habits of the aphids were also recorded. The data obtained in 1932 were used in the computations, since the record was not complete in 1931.

PRESENTATION OF DATA AND DISCUSSION.—Observations made during the two seasons indicate that the aphids attack the sorghum plants

very early in the spring. Sorghums planted earlier than May 1st at Manhattan do not germinate readily and grow very slowly, but these insects may be found on the plants which are above the surface of the ground on or about May 10. The dates of their appearance on the sorghum plants vary with the season.

The aphids found on the plants infested the curl. In many instances none could be seen unless the inner leaves of the plant were carefully unfolded. The tender portions of the newly developing leaves proved to be the most attractive to them.

A careful examination of the data secured indicates that the aphids remained on the sorghums the greater part of the season. The accompanying table records the number of both winged and wingless aphids present on five stalks each of dent corn in Row 1; Atlas sorghum, Row 2, and sweet corn, Row 3, in each series when the thirteen counts were made. Since the relative infestations on the other two varieties were similar to Atlas, the latter was selected as a representative variety to demonstrate the seasonal activities of the aphids.

The largest number of aphids found on the Atlas variety was recorded in the count made on June 17, 1932, with the greatest infestation occurring on the plants in the second series. The population began building up on the sorghums on the first three series and reached its peak by June 17. It will be noted that the dates of planting of the second and third series are only four days apart. One might expect very little difference in the infestations of these two series, but, on the contrary, considerable variation occurred.

Very few aphids were found on the first and the third series of sorghums and corn when the count was made on June 24. However, the fourth series, planted May 23, had the heaviest infestation. This count was characterized by a scarcity of winged individuals on the six series examined.

Observations for June 10 and June 17 showed winged individuals present on the plants of the third and fourth plantings. However, throughout the season, the number of winged individuals rarely exceeded one or two to the stalk each time counts were made until August 8, at which time the number approximated 100 to the stalk on the dent corn, and 15 to the stalk on the Atlas sorghum. The total infestation became greater as the number of winged females increased.

The observations made on June 24 indicated very few aphids present on both the sorghums and corn except on the plantings made May 23. The notes taken at that time revealed a uniform absence of winged forms on all varieties, while those present were concentrated on the corn

TABLE 1. NUMBER OF APHIDS PRESENT ON FIVE STALKS TAKEN FROM EACH SERIES AT WEEKLY INTERVALS THROUGHOUT THE SUMMER

Date counts were made		Date on Which Each Series was Planted																					
		1st Series April 30			2nd Series May 11			3rd Series May 14			4th Series May 23			5th Series June 1			6th series June 8			7th Series Aug. 1		
	Row number	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
1. June 3	Winged	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Wingless	0	203	14	0	81	0	0	7	0												
2. June 10	Winged	0	0	1	1	0	3	7	4	3	0	1	1									
	Wingless	4	352	0	0	160	7	0	121	4	0	19	1									
3. June 17	Winged	1	0	0	0	0	0	0	0	2	5	1	3	1	1							
	Wingless	20	397	4	3	508	0	1	280	0	7	65	6	0	13	0						
4. June 24	Winged	1	1	0	1	0	0	0	0	0	2	0	3	2	1	1	1	0	0			
	Wingless	0	14	0	21	16	0	8	75	3	2	310	0	3	79	0	0	0	3			
5. July 1	Winged	12	0	1	8	0	1	5	5	4	8	0	8	5	0	4	3	2	2			
	Wingless	196	41	0	69	22	1	32	21	21	48	121	79	29	370	24	13	37	0			
6. July 9	Winged	0	0	0	0	0	0	0	0	0	0	1	2	2	0	6	2	0	0			
	Wingless	0	112	0	381	232	0	87	58	0	30	0	6	20	0	0	6	53	0			
7. July 15	Winged	0	0	0	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0			
	Wingless	0	221	0	1	7	0	7	36	0	22	48	0	0	1	13	0	191	0			
8. July 22	Winged	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	3	5	6			
	Wingless	164	10	0	0	41	0	0	25	0	6	67	0	5	62	0	1	246	4			
9. July 29	Winged	None			None			0	0	0	7	3	5	1	1	0	0	3	3			
	Wingless							0	11	0	0	259	0	45	146	0	67	566	64			
10. Aug. 8	Winged							None			0	0	0	53	58	0	500	85	88			
	Wingless										0	10	0	464	496	0	370	742	0			
11. Aug. 15	Winged										0	0	0	0	0	0	0	2	0			
	Wingless										0	19	0	0	3	0	0	38	0			
12. Aug. 23	Winged										None			0	0	0	0	0	0			
	Wingless													0	4	0	0	67	0			
13. Aug. 29	Winged													0	0	0	0	0	0	0	1	1
	Wingless													0	307	0	0	268	0	0	86	3

Pride of Saline — Atlas Sorghum — Stowell's Evergreen

plants. Counts made on July 1 revealed a majority of the aphids, both winged and wingless, on the corn plants of the first three series. Apparently they transfer their attacks from the sorghums to the corn at this stage of growth. The tassels on the first three series had begun to appear in the curl on the stalk at that time. The aphids were attracted to the curl of the corn plants and the records show a sudden decrease in the number of aphids on the sorghums of the same series. Sorghums planted May 23, June 1, and June 8 were heavily infested, while the corn planted at the same time showed a very light infestation.

More aphids were found on the dent corn variety throughout the season than on the sweet corn. Counts made on July 9, 15, and 22, after the tassels of the early series of corn had begun to appear, showed a concentration of the aphids on the early planted sorghums. At the same time they also maintained a heavy infestation upon the less mature plants in the fourth, fifth and sixth series.

The population was again characterized by an absence of winged individuals, except on the fifth and sixth series. Sorghum plants in the first two series had begun to show evidence of heading when the counts were made on July 15, at which time the aphids were very scarce on both the sorghums and corn. From July 29 until the last count was made on August 29, no aphids were taken on either the sorghums or corn plants in the first three plantings. When the plants were examined on August 29, aphids were present on the fifth, sixth and seventh series. They were also found on suckers which had been produced at the nodes of the more mature sorghum plants in the first four plantings, but none were found on the corn.

Summary

(1) The summer behavior of *Aphis maidis* Fitch indicated that it is primarily a pest of sorghums.

(2) The aphids remained on the sorghums throughout the summer when immature plants were present in the fields.

(3) *Aphis maidis* Fitch was found on the corn for only a brief period prior to the appearance of the tassels.

(4) The shift in the population of the aphids from the sorghums to the adjoining corn and back to the sorghums followed the production of large numbers of winged forms. The peak in the numbers of these forms occurred July 1 and August 1 in the investigations conducted in 1932.

(5) The aphids showed a preference for dent corn over sweet corn and for sorghums over corn when the entire season was considered as a whole.

A DEVICE FOR REGULATING THE QUANTITY OF LIQUID USED IN SPRAYING

By OLIVER I. SNAPP and J. R. THOMSON, *U. S. Bureau of Entomology, Fort Valley, Georgia*

In both experimental and commercial spraying for the control of insects and diseases there has been a distinct need for a device to regulate under pressure the quantity of liquid used on each unit treated. The writers have given considerable attention to such a device in connection with investigations involving the use of paradichlorobenzene-crude cottonseed oil emulsion and other soil fumigants for the control of the peach borer (*Aegeria exitiosa* Say) working in the trunk and roots of peach trees under ground. As a result, an apparatus has been perfected which will spray out under pressure accurate quantities of the liquids used.

This apparatus operates in a similar manner to the cylinder in a steam engine. Two valves are geared together (Fig. 86) and are reversed

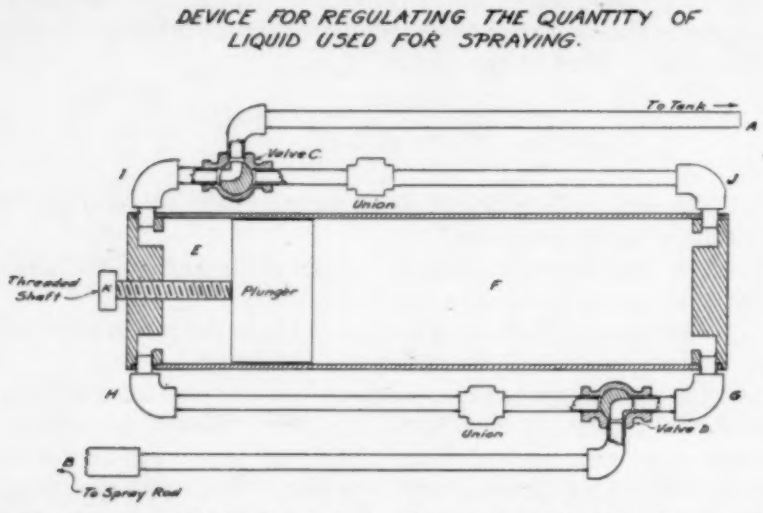

FIG. 86. Diagram of device for regulating the quantity of liquid used in spraying.

simultaneously by one push on a lever. With valve C (diagram) in the position to direct the flow of liquid from the tank through pipe I into chamber E, assuming of course that chamber F is already full of solution, force is exerted on the plunger which pushes it forward and forces the liquid contained in chamber F out through pipe G, valve D, pipe B, and the spray rod. Chamber E is then full of liquid at the end of this operation. When the lever is pushed, reversing simultaneously valves C and D, the flow of the liquid is changed and directed through pipe J into chamber F, which pushes the plunger back, expelling the liquid contained in chamber E out through pipe H, valve D, pipe B, and the spray rod.

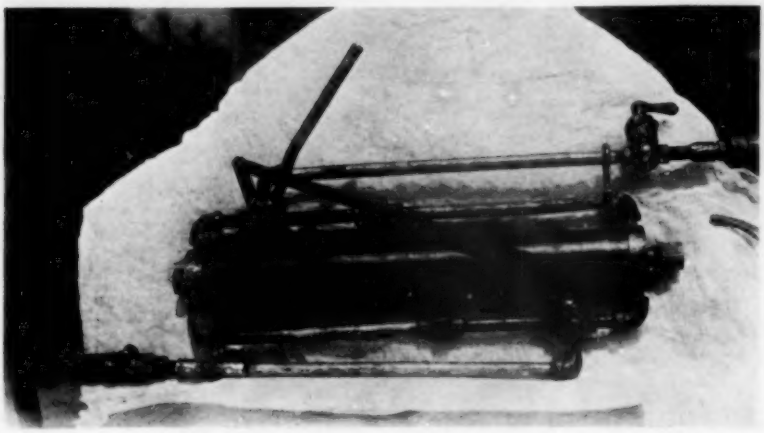

FIG. 87. General view of device.

In one end of the metal cylinder is inserted a threaded shaft (K) which regulates the length of the plunger stroke. By changing the lengths of this the quantity of liquid expelled by each stroke of the plunger is changed. The greatest capacity of the device illustrated by the digrammatic drawing is one quart; however, the same principle can be utilized for a device with a capacity of several gallons, in which case the attachment should be made on the sprayer between the tank and spray hose instead of between the spray hose and spray rod as illustrated for the apparatus with maximum capacity of one quart.

This device has been thoroughly tested for both experimental and commercial spraying (Fig. 88), and found to be very accurate, easily

handled and operated, efficient, practical, and entirely satisfactory for spraying a definite quantity of liquid on each unit to be treated.

FIG. 88. Using the device for regulating the quantity of liquid used in spraying.

A METHOD OF STUDYING COMPARATIVE OIL DEPOSITS OF PROPRIETARY OIL EMULSIONS

By ARTHUR D. BORDEN[1] and GEORGE S. HENSILL[2]

Oil emulsion sprays are known to vary considerably in their insecticidal values at given concentrations. Although this has been recognized for years in field work, the reasons for these variations were not established until studies of oil deposits of these emulsions were made.

Oil emulsions are generally classed as 'tight' and 'quick-breaking'. The former type is one in which the oil is securely held in the emulsion and the size of the oil droplets in the dilute spray is relatively small and uniform. The quick breaking type is one in which the oil is less securely held and the oil droplets in the dilute spray may be relatively large and

[1]Division of Entomology and Parasitology, University of California.
[2]Division of Entomology and Parasitology, University of California.

irregular in size. Although commercial oil emulsions are usually only classified in this manner, there are other important characteristics that must be considered.

The particular group to which an emulsion belongs is determined by the kind and amount of emulsifier used. Because of the fact that the chemical properties of commercial emulsifiers are a trade secret, little is known concerning their oil depositing characteristics. The value of such emulsions in terms of oil deposit can only be ascertained by experiment.

The amount of oil deposited on a surface by any given emulsion is in general indicative of its value as an insecticide. Oil deposit studies in the laboratory of both dormant and summer oil emulsions used on deciduous fruits in northern California have shown very definitely a variation in deposit. Correlated field studies show that those oil emulsions giving low oil deposits in the laboratory have comparatively low insecticidal values, and those giving higher oil deposits have a higher insecticidal value. The orchardist has little or no direct knowledge of the oil depositing characteristics of the commercial emulsions he uses. Purchase is usually made strictly upon a price basis or upon sales recommendation regardless of their true insecticidal value. Both the spray manufacturer and the orchardist should know the oil depositing properties of these products so as to insure satisfactory results.

It is the purpose of this investigation to ascertain the variation in the oil depositing properties of commercial emulsions, using both laboratory and field tests.

PREVIOUS METHODS.—A study of the literature indicates that there have been very few investigations of the oil depositing properties of oil emulsions. Smith[3] describes a precision sprayer used in his studies of oil deposits of emulsions used on citrus orchards in southern California. It is essentially a spray chamber capable of withstanding 300 pounds pressure and fitted with an agitating device which is operated by an electric motor, with suitable gear reducing units. The pressure was provided by air compressor equipment. Air pressures in the tests were from 50 to 175 pounds. The spray nozzle was held in a fixed position 24 inches distant from the surface sprayed. Sections of lightweight window glass, each 3½ by 7 inches in size were used as a standard surface to be sprayed.

[3]Ralph H. Smith, Studies on the Oil Depositing Qualities of Oil Spray Mixtures. Jour. Econ. Ent., vol. 24, 5, p. 985, Oct. 1931.

Ralph H. Smith, The Tank-Mixture method of using oil spray. Univ. Calif. Bul. 527, May 1932.

The difficulties arising in the use of this equipment are that in using compressed air over the liquid to be sprayed, even under relatively low pressures, too much air is whipped and dissolved into the solution, and also on plain glass plates of the size used, relatively low deposits of less

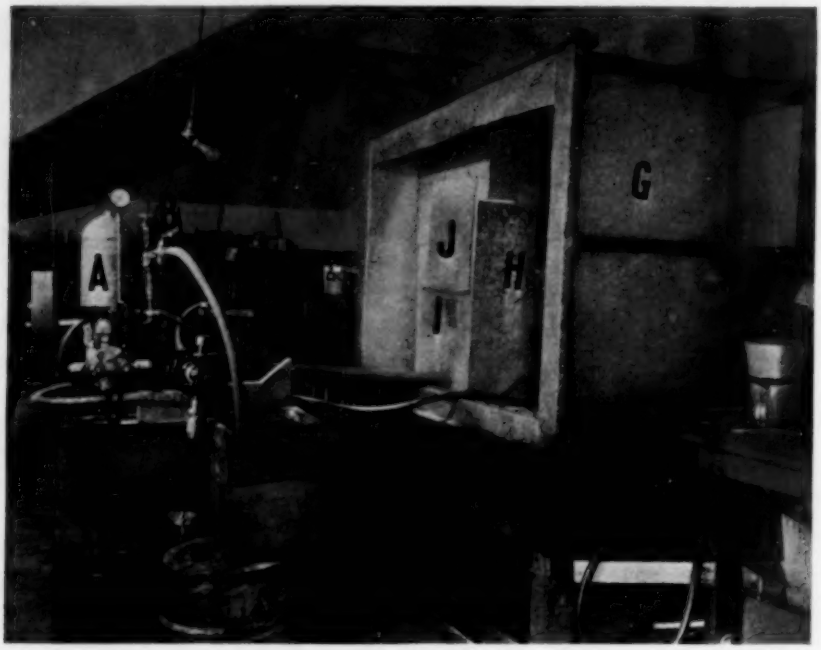

FIG. 89. Laboratory spraying apparatus showing arrangement of equipment.

uniform amounts are obtained. The volume of air passing through the nozzle with the spray liquid tends to break up the discharge into a fine fog which is not characteristic of orchard practice.

Another type of equipment developed in the Colloidal Products Corporation laboratories may be described as one type of 'paint-sprayer' in which the liquid is sucked up into a stream of compressed air and leaves the nozzle as a fog spray. Here again the volume of air disrupts the oil globules and produces a spray very dissimilar to that of a spray gun.

The type of equipment used in this study is as nearly as possible an exact duplicate of standard orchard equipment. It delivers the spray under normal atmospheric conditions at a constant pressure.

METHOD USED IN THIS STUDY.—The apparatus used in these laboratory experiments consisted of a Myers Horizontal Double Acting Spray Pump (Figure 89A), with a capacity of 5 to 7 gallons per minute, with Myers Pressure Regulating Valve (Figure 89B) and overhead suction line (Figure 89C); a 1 h.p. repulsion-induction motor and a 5-gallon capacity spray tank (Figure 89D), fitted with motor driven agitator (Figure 89E). The Vermorel nozzle (Figure 89F) at the end of the single lead of spray hose was mounted in a stationary position 38½ inches from the object to be sprayed. All of the above equipment was mounted on a large, heavily constructed table. A large sheet metal hood (Figure 89G) placed over a sink caught and carried off all excess spray. In this hood was erected a sheet metal partition (Figure 89H) perpendicular to the line of spray and 32½ inches from the nozzle in which was cut an opening (Figure 89I) 4 inches by 5 inches in the direct line of spray. Sliding on this partition and in front of the opening was a sheet metal plate (Figure 89J) of 15 inches by 18 inches dimensions which served to open and close the aperture in the partition. The sheet metal plate was raised and lowered by a system of cord and pulleys from the outside of the hood. In back of the partition of the hood was mounted in an inverted position a spring tension motor with a governor. This motor was obtained from an old player piano. The inverted mounting of this motor left the drive shaft in a perpendicular position parallel to the opening of the partition. A rubber cork fitting the opening of a 4 ounce oil sample bottle was fastened to the end of the drive shaft of the motor. A bottle when placed on this cork was exactly in line with the opening in the partition and the line of spray and turned at a uniform speed.

By raising the metal plate in front of the partition the bottle turning at 18–20 revolutions per minute could be exposed to the spray for any desired length of time. By lowering the metal plate, the spray could be instantly shut off from the bottle. An opening in the side of the hood facilitated placing and removal of bottles and winding the motor of the turning apparatus. A shut off was placed on the spray line just back of the nozzle so as to conserve spray during the change of bottles (Figure 89). Before spraying each bottle the spray line was opened and allowed to run a few seconds. The distance from the nozzle opening to the bottle was 38½ inches and the size of the disc opening in the nozzle was approximately $\frac{3}{64}$ inch. The nozzle was adjusted so as to give a narrow driving spray rather than a wide cone spray which would tend to mist.

All tests reported in this study were made at 100 pounds pressure at the pump. All bottles were exposed to the spray for 15 seconds and 24 bottles per test were used, in case of dormant oil emulsion, and 12

bottles in summer oil emulsion tests. Dormant oil emulsions were tested at 5 per cent concentrations and summer oil emulsions at 1 per cent concentrations. In all cases bottles were dried at room temperature (approximately 70°F.) for 48 hours, weighings being made at 24 and 48 hours after spraying. The bottles were dried by suspending them on wire hooks from wire lines strung across one corner of the room.

The bottles used in these tests were regulation 4 ounce oil sample bottles which have an area of 24.4 square inches on the sides and bottom after deducting the area of neck and top. The bottles were coated with a thin film of pure white beeswax. This was accomplished by heating the bottles to 100° C in an electric oven and then dipping them just over the shoulder in high melting point beeswax melted at the same temperature. After dipping the bottles are hung on wires in the oven at the same temperature for approximately 10 minutes to drain and insure a thin even film of wax. The bottles are then cooled at room temperature for at least 2 hours before weighing and spraying to insure complete hardening of wax. The average amount of wax left on the bottle by this method is from .25 to .3 grams.

The determination of the amount of oil deposited by a given spray is made in the following manner. Newly waxed bottles are weighed on a chainomatic balance to .1 mg. As soon after weighing as possible, the bottles were sprayed, allowed to dry for 24 hours, reweighed, allowed to dry another 24 hours, and a final weight taken. The difference between the 48 hour weight and the weight before spraying gives the amount of oil deposit per bottle. The average of the amount of oil deposit for the number of bottles used in each test is taken as the comparative oil deposit of the product under consideration. In this manner very accurate results can be obtained by wiping the necks of the bottles before weighing and using much care in handling and manipulation of bottles.

It is realized that the oil deposit of any one emulsion will vary on different surfaces but whereas one definite uniform type of surface is employed in these tests it does give a comparative value for all types of emulsions. The difficulties experienced in studying deposits on leaves, fruit, bark, etc., due to evaporation, shrinkage and other irregularities, makes it almost impossible to obtain uniform results.

The following table (Table 1) shows the data obtained in testing a standard commercial dormant oil emulsion at 5 per cent concentration, exposure 15 seconds per bottle, and pressure of 100 pounds.

Table 2 shows data obtained in testing a standard commercial summer oil emulsion at 1 per cent concentration, 15 seconds exposure, and 100 pounds pressure.

TABLE 1. OIL DEPOSIT DORMANT OIL EMULSION NO. 6

Bottle No.	Weight of bottle gms.	Weight after 24 hours gms.	Deposit mg.	Weight after 24 hours gms.	Deposit mg.
1	82.9940	83.0476	53.6	83.0457	51.7
2	89.3900	89.4440	54.0	89.4427	52.7
3	90.4981	90.5501	52.0	90.5491	51.0
4	96.4426	96.4975	54.9	96.4960	53.4
5	93.3337	93.3838	50.1	93.3829	49.2
6	83.1497	83.2048	55.1	83.2043	54.6
7	85.9728	86.0290	56.2	86.0283	55.5
8	92.3194	92.3700	50.6	92.3685	49.1
9	101.6482	101.7006	52.4	101.6991	50.9
10	94.0101	94.0614	51.3	94.0588	47.8
11	85.2757	85.3298	54.1	85.3278	52.1
12	77.2617	77.3098	48.1	77.3077	46.0

Average deposit after 24 hours 52.7 mg.
Average deposit after 48 hours 51.2 mg.

TABLE 2. OIL DEPOSIT OF COMMERCIAL SUMMER OIL EMULSION NO. 20

Bottle No.	Weight of bottle gms.	Weight after 48 hours	Oil deposit in mgs.
1	36.117	36.137	20.
2	32.927	32.946	19.
3	32.190	32.212	22.
4	41.652	41.674	22.
5	36.985	37.009	24.
6	27.637	27.655	18.
7	34.626	34.644	18.
8	38.395	38.414	19.
9	39.205	39.227	22.
10	34.975	34.997	22.
11	34.280	34.301	21.
12	37.956	37.974	18.

Average oil deposit after 48 hours 20.4 mg.

TABLE 3. OIL DEPOSIT OF STANDARD PROPRIETARY DORMANT OIL EMULSIONS—TWENTY-FOUR BOTTLES TO EACH TEST

Emulsion No.	Viscosity Say—100	Unsulph. residue	Deposit in mg. per bottle
1	104	73	32.6
2	87	69	24.4
3	115	67	25.0
4	112	71	37.0
5	105	78	55.6
6	113	63	51.2
7	122	68	53.6
8	133	76	47.4
9	110	71	28.4
10	105	68	41.6
11	132	68	39.9
12	105	81	23.0
13	103	78	22.0
14	102	70	47.9

TABLE 4. OIL DEPOSITS OF PROPRIETARY SUMMER OIL EMULSIONS

Emulsion No.	Viscosity Sec.-Say. 100	Unsulph. residue	Deposit in mg. per bottle
1	62	91.6	28.0
2	102	99.2	18.0
3	70	92.	8.7
4	69	95.6	16.0
5	62	95.	7.0
6	99	100.	20.4
7	52	95.6	5.6
8	66	94.	5.4
9	78	93.	4.0
10	78	94.8	8.1
11	56	95.6	5.3
12	69	94.	4.7
13	42	98.	18.0
14	57	88.	7.6
15	94	93.	15.
16	69	95.6	32.1

RESULTS OF LABORATORY OIL DEPOSIT TESTS.—A. *Proprietary Dormant Oil Emulsions.*—The wide variation in this group of dormant sprays is well shown in Table 3. There is two and one-half times as much oil deposited by the product giving the highest oil deposit and the product of lowest oil deposit, yet they are commonly recommended for identical purposes at the same concentrations.

B. *Proprietary Summer Oil Emulsions.*—Table 4 gives the results of tests with standard proprietary summer oil emulsions. In this group there is a variation of 4 to 28 mg. per bottle—a difference of seven times as much oil deposited by two different emulsions. A variation of from 15 to 28 mg. is shown in two emulsions, using the same grade of light medium oil.

RESULTS OF FIELD TESTS WITH DORMANT OIL EMULSIONS.—Though general observations have frequently shown a variance in the results obtained with different brands of emulsions in the same orchard in the control of the same insect, no attempt has been made previously, to correlate the efficiency in control with the oil depositing properties of the emulsions. The following table (Table 5) shows how the insecticidal value of any emulsion may be correlated with its oil depositing property. These tests were conducted in the same orchards.

TABLE 5. RESULTS OF FIELD TESTS WITH DORMANT OIL EMULSIONS AT 5 PER CENT CONCENTRATION ON SAN JOSE SCALE

Emulsion number	Oil deposit in laboratory test	Per cent kill San Jose scale
7	53.6	97
14	47.9	94
3	25.0	87
4	37.	92

DISCUSSION.—This study has shown that oil emulsions are recommended for use without regard to the oil depositing properties. Some manufacturers offer two or more brands of emulsions which have practically the same stock oil and yet similar oil depositing properties. This practice is confusing to the user and impractical, for it would be better if only one emulsion of each type were offered.

There are offered to orchardists several brands which are so low in oil depositing properties that their value as insecticides is questionable. Emulsions of low depositing properties cost within a few cents as much as those of high deposits and yet are sold in competition with the better grades for similar purposes.

The manufacturer of these spray products should pay more attention to the oil depositing properties and undoubtedly would profit by doing so.

Most of the uneven results obtained in field work with oil sprays are undoubtedly explained by the wide variations in oil deposition. This is without doubt due to the many types of emulsifying agents which are used in commercial manufacture of oil emulsions.

Up to the present time there is a decided lack of standardization of commercial oil sprays as there has been no definite necessity for the standardization of oil emulsions regarding these characteristics.

As the necessity for more rigid insect control becomes manifest, it may be essential to standardize oil emulsions on the basis of their oil depositing qualities in order to effect satisfactory insect control in all cases.

There is no doubt, on the basis of this work, but that studies of this type are important as regards oil sprays and that the use of these studies will develop along with further developments in oil sprays and their use in insect control.

THE RELATIVE EFFICIENCY OF SOME FUMIGANTS AGAINST THE RICE WEEVIL AND THE CONFUSED FLOUR BEETLE[1]

By HAROLD H. SHEPARD and DAVID L. LINDGREN, *University of Minnesota, St. Paul, Minnesota*

In 1932, propylene dichloride was advertised as superior to carbon disulphide for use in the control of grain weevils and other insect pests of stored products. Results published by Neifert et al (1925) formed the basis of this claim, although it is not possible to estimate very exactly from their published data the relative effectiveness of the individual substances tested. Because their tests were made at relatively widely separated concentrations, the order of toxicity as given was attended by a considerable degree of error. Any advantage in toxicity that propylene dichloride might have over other substances is exaggerated somewhat by the arrangement of the various compounds on the basis of their effective concentrations expressed in terms of molecular percentages rather than in those used in the practical application of fumigants, namely, weights in grams or pounds.

EXPERIMENTAL METHOD.—The method of Strand (1930) was followed in the experiments here reported. Temperature was maintained constant at 25 degrees Centigrade. Other factors were controlled mainly by conducting tests simultaneously with insects from the same culture. The ethylene dichloride and its mixture with carbon tetrachloride were kindly furnished by the Carbide and Carbon Chemical Corporation, and the propylene dichloride and its corresponding mixture by the Dow Chemical Company. Samples were purchased from the Eastman Kodak Company for comparison with the preceding ones. The pipettes for measuring the fumigants were graduated to 0.01 cubic centimeter. Specific gravity data, determined for the average temperature of our basement laboratory, which remains very uniformly at 23.5 to 25.0 degrees Centigrade during most of the year, are as follows: carbon disulphide, 1.256; ethylene dichloride, 1.246; 75 per cent mixture of the latter with carbon tetrachloride, 1.326; propylene dichloride, 1.133; the corresponding mixture with carbon tetrachloride, 1.310; and carbon tetrachloride, 1.586. In order to have comparisons with familiar fumigants, carbon disulphide and carbon tetrachloride were included in this study. Each toxicity curve represents the results of at least twenty tests on groups of 30 to 60 insects. A total of 3550 insects

[1]Paper No. 1204 Scientific Journal Series of the Minnesota Agricultural Experiment Station.

were used in comparing the effects of five-hour exposures of *T. confusum* to ethylene and propylene dichlorides. The influence of the presence of adsorptive material such as grain was not studied.

RESULTS AND DISCUSSION.—In the following table are included the median lethal concentrations in milligrams per liter for adults of *Sitophilus oryzae* Linn. (rice weevil) and *Tribolium confusum* Duv. (confused flour beetle) after exposure both for five and for twenty-four hours. Also are listed the approximate concentrations at which 95 to 100 per cent of the insects were killed. Because toxicity curves are not necessarily parallel to each other the concentrations producing complete or nearly complete mortality have a closer relation to practical requirements than the median concentrations, notwithstanding the greater precision and reproducibility of the latter.

TABLE 1. THE RESULTS OF THE EXPOSURE OF ADULTS OF *Sitophilus oryzae* AND *Tribolium confusum* TO CERTAIN FUMIGANTS. TEMPERATURE, 25 DEG. C.

Compound	5-hour Exposure		24-hour Exposure	
	50 per cent mortality	100 per cent mortality	50 per cent mortality	100 per cent mortality
S. oryzae:	mg./liter		mg./liter	
Carbon disulphide	23	30	9	15
Ethylene dichloride	35	100	10	32
Propylene dichloride	45	100	19	28
Ethylene dichloride (75 per cent mixture)	60	180	33	65
Propylene dichloride (75 per cent mixture)				
Carbon tetrachloride	142	350	55	100
T. confusum:				
Carbon disulphide	61	73	15	19
Ethylene dichloride	35	60	12	30
Propylene dichloride	43	73	23	33
Ethylene dichloride (75 per cent mixture)	57	100	15	30
Propylene dichloride (75 per cent mixture)	73	110	33	38
Carbon tetrachloride	200	350	—	—

Curves showing the results of five-hour exposures of *Sitophilus oryzae* and of *Tribolium confusum* to ethylene dichloride, propylene dichloride and carbon disulphide are given in Figure 90. In the lower graph each point in the curves for ethylene and propylene dichlorides is an average of several determinations at the same concentration.

In several repeated determinations of their respective toxicity curves, propylene dichloride was always found to be slightly less effective than ethylene dichloride except near the point of complete mortality of *S. oryzae*. On the other hand when the data for five-hour exposures of *T. confusum* to these fumigants are plotted in terms of molecules the curves appear to coincide. In the table the figures for efficiency of the usual

non-inflammable 75 per cent mixtures of these compounds with carbon tetrachloride show a considerable reduction in toxicity. For *S. oryzae* the effects of the respective mixtures are indistinguishable whereas for *T. confusum* the ethylene dichloride mixture is the more effective.

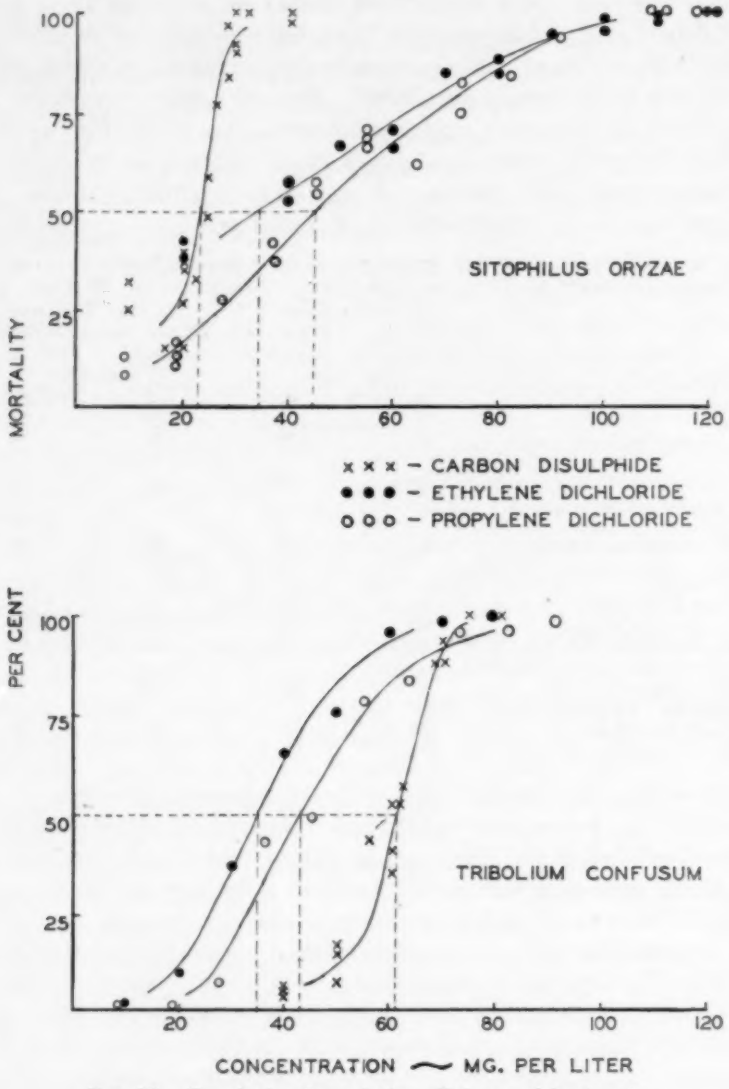

FIG. 90.—Graph showing relative efficiency of fumigants.

From Figure 90 it is apparent that carbon disulphide is more toxic to *S. oryzae* than are ethylene and propylene dichlorides. In the case of *T. confusum* the relationship is reversed, carbon disulphide being less toxic. It is therefore impossible to generalize in much detail regarding the relative toxicity of various fumigants. Recently other workers have found this to be true in the case of stomach insecticides.

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BORDEAUX-OIL SPRAYS AS REPELLENTS TO THE LESSER BULB FLY

By F. S. BLANTON, *Junior Entomologist*, and F. J. SPRUIJT, *Assistant Entomologist, Division of Truck Crop and Garden Insects, U. S. Bureau of Entomology*

The experiments described herein were made in an attempt to determine the value of certain dilutions of oils in combination with a 4–4–50 Bordeaux mixture as repellents to the lesser bulb fly (*Eumerus tuberculatus* Rond.). Mixtures of Bordeaux with 2 and 4 per cent of oil, respectively, and undiluted 4–4–50 Bordeaux were used on three varieties of narcissus bulbs, namely, Bicolor Victoria, Tresserve, and King Alfred.

The bulbs were planted in Dutch beds, 100 bulbs to the bed. Some of the beds were given five applications of the spray at intervals of 2 weeks and the others were given four applications at intervals of 3 weeks. The material was applied with a knapsack sprayer having a small mist-spray nozzle. For the first application 1 pint of material was used for each bed, but as this quantity did not completely cover the foliage, 1 quart was used thereafter. When 1 quart was used the foliage was completely covered with the mixture. All beds received the first spray on May 23, 1932. The bulbs were weighed before planting and again after harvesting and curing.

The weight increase, together with the percentage of rotten and fly-infested bulbs, is given in Table 1.

TABLE 1. INCREASE IN WEIGHT AND PERCENTAGES OF LESSER-BULB-FLY INFESTATION AND BASAL-ROT INFECTION FOLLOWING TREATMENT WITH BORDEAUX-OIL SPRAYS AND WITH STRAIGHT 4–4–50 BORDEAUX MIXTURE

Variety of bulbs	Treatment: Kind of spray	Applications per week	Bulbs dug	Combined weight of bulbs: When planted	When dug	Increase	Bulbs infected with basal rot	Bulbs infested by bulb-fly larvae
		Number	Number	Ounces	Ounces	Per cent	Per cent	Per cent
Victoria	4 per cent Bordeaux-oil	2	100	101	144	42.6	17.0	15.0
	4 per cent Bordeaux-oil	3	97	63	96	60.3	30.9	21.6
	2 per cent Bordeaux-oil	2	100	83	159	91.6	20.0	11.0
	4–4–50 Bordeaux[a]	2	90	74	172	132.4	4.4	4.4
	Check		96	70	152	117.2	20.8	9.4
Tresserve	4 per cent Bordeaux-oil	2	100	214	315	47.2	6.0	3.0
	4 per cent Bordeaux-oil	3	100	208	296	42.3	4.0	3.0
	2 per cent Bordeaux-oil	2	100	194	370	90.7	11.0	9.0
	4–4–50 Bordeaux[a]	2	100	179	418	133.5	4.0	4.0
	Check		100	198	359	81.3	6.0	4.0
King Alfred	4 per cent Bordeaux-oil	2	100	288	475	64.9	6.0	6.0
	4 per cent Bordeaux-oil	3	95	242	392	62.0	7.4	7.4
	2 per cent Bordeaux-oil	2	100	208	424	103.8	5.0	4.0
	4–4–50 Bordeaux[a]	2	97	214	504	135.5	4.1	4.1
	Check		95	224	444	98.2	6.3	5.3

[a]Straight Bordeaux mixture.

It will be seen from the table that in all cases the plots treated with the straight 4–4–50 Bordeaux mixture show a considerable increase in yield over the untreated plots. In King Alfred and Tresserve bulbs the 2 per cent Bordeaux-oil gave a greater increase in weight than the check, whereas in Victoria bulbs the check was better than the 2 per cent Bordeaux-oil. With 4 per cent Bordeaux-oil the weight increase was low in all varieties.

All the bulbs treated with the straight 4–4–50 Bordeaux mixture showed a decrease in basal-rot infection as compared with the same variety of untreated bulbs. In Victoria bulbs there was a much higher percentage of basal-rot infection with 4 per cent Bordeaux-oil than with the check when three applications per week were given; in the Tresserve and King Alfred varieties little difference is indicated when applied at either two or three week intervals. The 2 per cent Bordeaux-oil gave an increase in basal-rot infection of Tresserve bulbs over that given by the untreated bulbs, but the King Alfred and Victoria varieties showed little difference when given this treatment and when untreated.

The Victoria and King Alfred varieties showed a decrease in fly infestation when straight 4–4–50 Bordeaux was used. The fly infestation was much higher in Victoria bulbs treated with 4 per cent Bordeaux-oil than in untreated bulbs of the same variety, but in the Tresserve and King Alfred bulbs little difference is shown. The 2 per cent Bordeaux-oil increased the fly infestation on Victoria and Tresserve bulbs, but not on King Alfred bulbs.

Observations were also made as to the condition of the foliage and the length of time required for the bulbs to mature. The 4 per cent Bordeaux-oil gave considerable leaf burn and the foliage died earlier than with any of the other treatments. On the other hand, with the 2 per cent dilution the foliage remained green longer than in the untreated check. The foliage that received the straight Bordeaux mixture was the last to die and was still partially green at the time of digging, whereas with all the other treatments the foliage had been dead for at least two weeks.

CONCLUSIONS.—From these results we may conclude that Bordeaux-oil mixtures in 2 and 4 per cent dilutions applied to narcissus bulbs have no repellent effect on the lesser bulb fly. In the stronger dilution the oil is injurious to the foliage and possibly also to the bulbs. Fly infestation and basal-rot infection may be increased as a result of this injury. Straight 4–4–50 Bordeaux mixture not only keeps the plants in a healthy growing condition that reduces the chance of the larvae

entering the bulb, but also, to a certain extent, seems to stimulate and invigorate growth. It is not known whether the enormous increase in yield over the untreated plot when straight Bordeaux mixture is used is due to the control of foliage diseases, or to the absorption of a small amount of the copper by the foliage, which may serve as a stimulant to the bulb, or both.

AN INVESTIGATION OF SOLVENTS FOR THE REMOVAL OF LEAD ARSENATE RESIDUES FROM FRUITS

By R. H. CARTER, *Insecticide Division, Bureau of Chemistry and Soils, U. S. Department of Agriculture, Washington, D. C.*

Lead arsenate for some time has been the most commonly used insecticide in the control of insects affecting fruits and vegetables, and the residues left after its use, especially in arid or semi-arid regions, are a serious menace to health. Many washing processes have been developed to remove the residues but none has proved entirely satisfactory under all conditions.

It seemed desirable therefore to make a laboratory study of the solubility of lead arsenate in some of the commonly used apple-washing solutions and also to test such other new solvents as seemed practical.

The following procedure was adopted: Five-tenths gram of lead arsenate, or a larger amount if necessary, was weighed into an Erlenmeyer flask. One hundred cc. of the solvent being tested was adjusted to 20.0° C. and then added to the flask containing the lead arsenate, shaken by hand for one minute and then filtered by suction through a porous plate. Filtration was stopped at the end of two minutes and aliquots of the solution were then analyzed for lead and arsenic by standard methods. A one-minute period was selected for shaking as being approximately equivalent to the time of contact in commercial washing practices, which is generally from 30 to 50 seconds.

It must be kept in mind that this procedure permits only the determination of the lead and arsenic that actually goes into solution, and can give no information concerning the possible physical removal of spray residue by detergents, abrasives (sawdust) and brushes.

The lead arsenate used in these tests was a laboratory preparation of 100 per cent purity, having the composition $PbHAsO_4$.

A previous study of solvents for lead arsenate was made by Robinson (Ind. Eng. Chem. 21 : 1132. 1929) with a series of different acids and

solutions. In that investigation the acid solutions were all prepared on a percentage basis without regard to their normality. In the work described here the acid solutions were made to have a normality of 0.136, which is equal to that of the 0.5 per cent solution of hydrogen chloride commonly recommended for commercial use. Solutions of alkalies were made to this equivalent titrating strength or to other arbitrary concentrations as shown in the text. Solutions of salts were made up of various concentrations as indicated in the tables.

The materials studied were considered in the following classes: acids, mixed acids, acids plus salts, salts, alkalies, alkalies plus salts, and wetting agents.

(1) Acids.—Most of the common inorganic and some of the substituted organic acids were tested. The results are given in Table 1.

TABLE 1. SOLVENT ACTION OF ACIDS ON LEAD ARSENATE

Solvents and Concentrations		g. $PbHAsO_4$/100 cc. From As determinations	g. $PbHAsO_4$/100 cc. From Pb determinations
Hydrochloric acid, 0.5% soln	0.1359 N	.258	.250
Hydrofluosilicic acid*	0.1359 N	.050	.066
Perchloric acid	0.1359 N	.162	.164
Nitric acid	0.1359 N	.199	.188
Sulfuric acid	0.1359 N	1.822	.003
Sulfuric acid	0.0679 N	.852	not run
Chromic acid	.1359 N	1.666	.008
Phosphoric acid*	.1359 N	.030	.009
Acetic acid	.1359 N	.002	.002
Dichloracetic acid	.1359 N	.147	not run
Trichloracetic acid	.1359 N	.163	.147

*Hydrofluosilicic acid was considered hexavalent and phosphoric acid divalent because the indicator used was phenolphthalein.

Among the common inorganic acids, hydrochloric seems to be the most effective in dissolving both lead and arsenic, which apparently go into solution in the same ratio in which they are present in acid lead arsenate. Acids, such as sulfuric and chromic, which furnish an ion capable of forming an insoluble lead salt increase the amount of arsenic in solution but dissolve only a very small amount of lead. Phosphoric acid had little solvent action. The substituted organic acids were likewise poor solvents.

(2) Mixed Acids.—Results with mixtures of hydrochloric and various other acids are given in Table 2.

The addition of weak organic acids to hydrochloric acid does not materially increase the solvent action for either the arsenic or lead. When an ion capable of forming an insoluble lead salt is present (e. g., oxalate) an increase in the arsenic content of the solution is noted.

TABLE 2. SOLVENT ACTION OF MIXED ACIDS ON LEAD ARSENATE

Solvents and Concentrations	gr. $PbHAsO_4$/100 cc. From As determinations	From Pb determinations
Hydrochloric acid .0679 N+acetic acid .0679 N.....	.109	.099
Hydrochloric acid .1359 N.....	.258	.250
Hydrochloric acid .1359 N+boric acid 10 g./L.....	.275	not run
Hydrochloric acid .1359 N+citric acid 10 g./L.....	.271	not run
Hydrochloric acid .1359 N+lactic acid 10 g./L.....	.272	.247
Hydrochloric acid .1359 N+pyrogallic acid 10 g./L.	.272	not run
Hydrochloric acid .1359 N+1-malic acid 10 g./L....	.259	not run
Hydrochloric acid .1359 N+oxalic acid 10 g./L.....	.445	.004
Hydrochloric acid .1359 N+tartaric acid 10 g./L....	.272	.252
Hydrochloric acid .1359 N+phenol 10 g./L.....	.304	.246

(3) Acids plus salts.—Recommendations have been made by several investigators for the addition of salts to acid solutions to increase their efficiency. Sodium chloride in particular has been used quite extensively. Since the arsenites are generally more soluble than the arsenates it was thought that the presence of a reducing agent might materially increase the solvent action. A few tests of this type are reported in Table 3.

TABLE 3. SOLVENT ACTION OF ACIDS+SALTS ON LEAD ARSENATE

Solvents and concentrations	gr. $PbHAsO_4$/100 cc. From As determinations	From Pb determinations
Hydrochloric acid .1359 N.....	.258	.250
Hydrochloric acid .1359 N+sodium chloride 2 g./L.	.446	.199
Hydrochloric acid .1359 N+hydrazine sulfate 1 g./L.+sodium bromide 1 g./L.....	.411	.159
Hydrochloric acid .1359 N+hydrazine sulfate 1 g./L.	.422	.146
Hydrochloric acid .1359 N+sodium bromide 1 g./L.	.278	not run
Hydrochloric acid .1359 N+ammonium persulfate 10 g./L.....	.359	.187
Hydrochloric acid .1359 N+ammonium thiocyanate 50 g./L.....	.876	.034
Nitric acid .1359 N.....	.199	.188
Nitric acid .1359 N+sodium chloride 5 g./L.....	.273	.238
Nitric acid .1359 N+sodium chloride 10 g./L.....	.293	not run

The addition of salts to hydrochloric acid solution does not materially increase its solvent action. An increase in the amount of arsenic in solution may be predicted when using salts which furnish an ion capable of forming an insoluble lead salt, but there will be a decrease in the amount of lead in solution. Mellor ("Treatise on Inorganic and Theoretical Chemistry", vol. 7, p. 727) states that a low concentration of sodium chloride decreases the solubility of lead chloride, so use of this material except in high concentrations theoretically should not be of much benefit in removing lead from spray residues. The presence of reducing agents in the hydrochloric acid solution likewise did not prove of value.

(4) Salts.—Robinson (loc. cit.) has investigated quite thoroughly the action of aqueous solutions of salts and has reported that they have very little solvent action when used alone. Tests with salts are reported in Table 4.

TABLE 4. SOLVENT ACTION OF SALTS ON LEAD ARSENATE

Solvents and concentrations	g. $PbHAsO_4$/100 cc. From As determinations	From Pb determinations
Ammonium persulfate 10 g./L	.022	not run
Ammonium persulfate 100 g./L	.451	.002
Ammonium thiocyanate 50 g./L	.009	not run

Aqueous solutions of salts alone are apparently of little value.

(5) Alkalies.—Several alkaline salt solutions, such as sodium carbonate, borax, sodium phosphate, and sodium silicate, have been used more or less extensively for fruit washing. Sodium hydroxide alone has not been used much due to the danger of injury to the fruit. Some of the alkaline compounds were investigated briefly. The results are given in Table 5.

TABLE 5. SOLVENT ACTION OF ALKALINE SOLUTIONS ON LEAD ARSENATE

Solvents and concentrations	g. $PbHAsO_4$/100 cc. From As determinations	From Pb determinations
Calcium hydroxide saturated soln	.031	not run
Sodium hydroxide .1359 N	.399	.330
Ammonium hyrdoxide .1359 N	.025	.000
Sodium silicate .1359 N	.098	not run
Sodium silicate 8.8 g./100 cc. or 75 lbs./100 gal	.841	.739
Monoamylamine 50 cc./L	.045	.015
Diamylamine 50 cc./L	.016	.002
Triamylamine 50 cc./L	.013	.003

Among the alkaline solutions tested, sodium hydroxide was much the best at equivalent concentrations, being even better than hydrochloric acid in this respect. Sodium silicate at the concentrations recommended by several investigators (8.8% or 75 lbs. per 100 gal.) is a better solvent for both lead and arsenic than .5 per cent HCl. The sodium silicate used in these experiments was a commercial product having a ratio of Na_2O: SiO_2 = 1 : 1.58. This liquid silicate had a density of approximately 58.8° Baumé. Three organic amines which are strongly alkaline were tried without encouraging results. These were commercial products described by the manufactuurer as being mixtures of their respective isomers.

(6) Alkalies plus salts.—The addition of salts to acid solutions to increase their efficiency has been investigated quite thoroughly. The addition of salts to alkaline solutions has apparently not been gone into

very extensively and seems to offer a profitable field for investigation when it is known that certain lead salts of organic acids are soluble in alkaline solutions. A few results are reported in Table 6.

TABLE 6. SOLVENT ACTION OF ALKALINE SOLUTIONS PLUS SALTS ON LEAD ARSENATE

Solvents and concentrations	g. $PbHAsO_4$/100 cc. From As determinations	From Pb determinations
Calcium hydroxide sat. soln.	.031	not run
Calcium hydroxide sat. soln.+sodium thiosulfate 10 g./L.	.012	not run
Calcium hydroxide+potassium ferricyanide 10 g./L.	.005	not run
Sodium hyrdoxide .1359 N	.399	.330
Sodium hydroxide .1359 N+sodium chloride 10 g./L.	.448	.402
Sodium hydroxide .1359 N+sodium thiosulfate 10 g./L.	.382	.374
Sodium hydroxide .1359 N+potassium ferricyanide 10 g./L.	.334	.282
Sodium hydroxide .1359 N+ammonium thiocyanate 50 g./L.	.203	.003

Sodium chloride increased the solvent action of sodium hydroxide, and there is a possibility that other salts may be of practical value.

(7) Wetting agents.—McLean and Weber (J. Econ. Ent. 24 : 1255. 1931) recommended the addition of a textile wetting agent or degumming soap to a hydrochloric acid solution in order to obtain better cleaning of apples. Some of these materials were obtained and tested in solution alone and in hydrochloric acid solution. (Table 7.)

TABLE 7. SOLVENT ACTION OF WETTING AGENTS WITH AND WITHOUT ACID ON LEAD ARSENATE

Solvents and concentrations	g. $PbHAsO_4$/100 cc. From As determinations	From Pb determinations
Hydrochloric acid .1359 N	.258	.250
Wetting agent No. 2 50 g./L.	.014	not run
Wetting agent No. 1 50 g./L.	.015	not run
Wetting agent No. 3 50 g./L.	.023	not run
Wetting agent No. 2 50 g./L.+hydrochloric acid .1359 N	.015	.106
Wetting agent No. 1 50 g./L.+hydrochloric acid .1359 N	.013	.059
Wetting agent No. 3 50 g./L.+hydrochloric acid. 1359 N	.048	.089

(1) A sulfonated abietene in the form of a powdered sodium salt.
(2) An alkylated naphthalene sulfonate of sodium.
(3) A degumming soap.

The textile wetting agents and degumming soap investigated had very little solvent action when used alone and even decreased the solvent action of the hydrochloric acid solution. The hydrochloric acid solutions containing these materials had the same titrating value against standard sodium hydroxide, phenolphthalein being used as indicator, as the acid

solution alone. However, the presence of these compounds may perhaps repress the ionization of the hydrochloric acid, making it less effective. The apparent discrepancy between these results and those obtained by McLean and Weber may perhaps be caused by the much greater ratio of acid to wetting agent used by them than was tested in this investigation. Theoretically, any increased efficiency due to the addition of these compounds is the physical effect of increased wettability rather than solvent action.

SUMMARY.—An investigation of the solubility of lead arsenate in different solvents must consider two angles, first, true solubility, in which the lead and arsenic go into solution in the same ratio in which they were present in the lead arsenate, and second, reactions in which one or both form other salts which are insoluble in the equilibrium mixture.

Most of the common inorganic acids are apparently strong enough to attack lead arsenate to a greater or less degree. Those which furnish ions capable of forming soluble salts with both lead and arsenic exert a true solvent effect. Hydrochloric acid was the best in this respect. Those which furnish ions capable of forming insoluble lead salts (such as sulfuric and chromic) are capable of dissolving more arsenic but a smaller amount of lead.

Organic acids are apparently too weak to exert a solvent action on lead arsenate but are capable of undergoing reactions with it, causing precipitation of insoluble lead salts. This is true also when the organic acids are mixed with hydrochloric acid.

Solutions of salts alone or when mixed with acids do not have an appreciable solvent action unless they also cause reactions forming other insoluble compounds. A high concentration of sodium chloride in hydrochloric acid may be of some benefit in dissolving lead chloride.

Some of the alkalies, especially sodium silicate and sodium hydroxide, are capable of dissolving appreciable quantities of both lead and arsenic. Weak alkalies, such as ammonium hydroxide and organic amines, do not have appreciable action.

The addition of salts to solutions of alkalies may be of some benefit and offers a field for further investigation.

The use of wetting agents and degumming soaps may be of some benefit in removing lead arsenate spray residues through the physical action of increased wettability but probably do not have much solvent action per se.

PAPER BARRIERS FOR CHINCH BUG CONTROL[1]

By H. M. HARRIS and G. C. DECKER

Since the time of the first recorded outbreak of the chinch bug (*Blissus leucopterus* Say) it has been recognized that the most feasible method of preventing or lessening injury by the migrating pests is in the use of fences which prohibit their entrance in numbers into the cornfields. These fences have taken many forms, all, however, being variations of the physical barrier (e. g., dusty furrow and sticky oil types) or of the chemical barrier (creosote line, gas tar, calcium cyanide, etc.). Gradually it has been shown that the most practical barrier under the varying conditions that prevail during a chinch bug outbreak is that known as the creosote furrow type, and it is this barrier that has become more or less standardized in chinch bug warfare during the past few years. There is no question concerning the effectiveness and thus the value of this type of barrier when it is properly constructed and properly maintained. Yet, it has certain weaknesses not the least of which is the fact that during strong breezes countless numbers of bugs may be blown over the line. In certain localities in Iowa where the Wabash loam, gumbo, or buckshot type of soil prevails it is often impossible to prepare an ideal furrow and ridge for the creosote barrier, and especially in these localities so many bugs are carried across the creosote line by the wind that the field worker is hard put to convince the farmer that a barrier actually will work. To surmount this difficulty the senior author began experiments in 1933 with a type of chinch bug fence which the writers have called the paper barrier. During the present season the use of approximately 115 miles of paper barrier in Madison County, Iowa has served to demonstrate its worth. While the paper barrier is still in the experimental stage of development, its potentialities appear so great that it seems desirable to call it to the attention of other workers.

This barrier consists of a strip of creosote-soaked paper placed upright in a groove and the soil pulled against it and tamped to the same level on both sides. Postholes are dug at intervals on the small grain side of the paper. They should be placed approximately four to six inches away from the paper and their edges should be sloped out to the paper and dusted the same as in the case of the chemical line barriers.

After many trials with paper of various widths, it has been established that strips of about 4½ inches are the most satisfactory. Since it

[1]Journal Paper No. J183 of the Iowa Agricultural Experiment Station, Ames Iowa. Project No. 420.

is best to leave about two inches of paper above ground, strips less than four inches wide necessarily are inadequately secured in the soil. Strips of five to six inches are satisfactory where they are placed so that not more than three inches of the paper stands above ground, but with wider strips too much is left above ground and this is conducive to excess rolling, falling, and tearing of the paper.

The manner of laying the paper in place will vary, usually depending on the tools at hand and the character of the soil. Where a wheel-hoe or garden cultivator with a small plow attachment is available, it may be used to open a small furrow to receive the paper. In many cases an ordinary corn cultivator with all but one large shovel removed was very successfully used to prepare a place for the barrier between two corn rows. When the paper is to be placed in very hard ground it is necessary to use a turnplow to open a shallow furrow. In this case the paper is unrolled against the straight or land side of the furrow and the dirt moved back against it to its original position. In any case it is very important to see that the dirt is packed firmly and evenly against both sides of the paper. When the dirt is left higher on one side rain or caving soil causes greater pressure on that side and results in the collapse of the paper. In general barriers constructed on the level are more satisfactory than those used in connection with a furrow and ridge. In the latter case some difficulty is experienced in preventing the soil on the furrow side of the paper from caving away and leaving that side of the paper unsupported.

By any of the above methods of procedure, two men can lay 80 rods of paper barrier in three to four hours. The labor cost of construction is no greater than the cost of constructing a good furrow type of barrier; and the initial cost of the paper is more than offset in the reduced quantity of creosote required to maintain the barrier.

In practice four types of paper have been used in building these barriers. Perhaps the greater majority were constructed with regular red rosin building paper. This may be had at most any lumber yard and comes in 36-inch rolls. It is readily cut with a saw and a roll (500 sq. feet) makes eight strips, each approximately 4½ inches wide and ten rods long. Red rosin building paper is usually available in three grades, weighing 20, 25, and 30 pounds per roll respectively. The 30 pound paper, which is the grade most commonly stocked by lumber yards, has the advantage of being thicker and stronger than the others and thus it is easier to use and stands up better. This year the heavy paper retailed in Iowa for $1.25 to $1.50 per roll. The chief advantages of red rosin paper over the others tried seem to be its greater availability and

lesser cost, a roll making approximately one-fourth mile of 4½ inch barrier.

Next to the resin sized paper asphalt saturated felt building paper was most available and therefore was used extensively. It is somewhat more expensive than the red rosin paper, and does not saw into strips quite so readily as it tends to gum the saw. This latter difficulty, however, may be remedied by widening the set of the saw. Under certain field conditions the asphalt felt seemed to soften and to roll more severely than any of the other papers used. It, too, comes in 36-inch rolls and in different weights, but a roll (144 linear ft.) will make only about 70 rods of 4½ inch barrier.

Regular tarred felt was the third type of material tried. It has the advantage over all the other papers used in that pre-soaking in creosote is not necessary since it already contains sufficient tar to turn the bugs. However, it is necessary to treat it occasionally during the height of the migration. Like the red rosin and asphalt saturated felt, tarred felt comes in several grades. The 14 pound material, weighing 60 pounds per roll of 144 linear feet retails in Iowa for about 60% more than the 30 pound red rosin paper. Many of the farmers feel that they were justified in using this higher priced material.

The fourth paper used was a single faced corrugated board of chip and straw composition. This paper was put down with the corduroy side toward the protected field. It has the advantages of greater rigidity and strength and is therefore more easily laid in place and forms a more permanent barrier in the face of wind and rain. Too, its double construction gives room for expansion without breaking gaps in the wall. This, a commendable feature lacking in the building papers, is accomplished through the corrugations expanding and straightening, thus lengthening the strip when contraction is so great as to rupture the straight ply. It requires more chemical for the initial treatment but in many ways is the best of the paper materials tried as chinch bug barriers. It does not seem out of the question, judging from the condition of the paper in some of these corrugated board barriers that have stood in the field for five or six weeks during which they were exposed to several rains, to suggest that the farmer could even roll the strips up and use them another year. This corrugated paper was purchased in 36-inch rolls, containing 250 lineal feet and weighing 65 pounds each. One of these will make approximately 120 rods of 4½ inch barrier at a cost of about $4.50 for the paper material. Corrugated board at present has the objectionable features of non-availability locally and of greater cost, but its advantages are such that if there is to be developed commer-

cially a chemically treated chinch bug paper for barrier construction it perhaps will be of this type.

In preparing the paper for use the rolls as purchased are cut into narrower rolls. The initial application of chemical is made, excepting in the case of the tarred paper, by soaking these narrower rolls directly in it. It is of advantage to allow these rolls to stand on end to drain and become somewhat dry before putting them in the soil. In making subsequent applications of chemical one may use a pail with a nail hole near the bottom in the side below the handle attachment, a knapsack sprayer, a paint brush, or a sprinkling can or tea kettle with the spout partly plugged. An effective and ingenious back-saving device is a pail with a short S-shaped copper tube attached near the bottom.

The more important advantages of the paper barrier over previously used chinch bug fences seem to be about as follows:

1. The effectiveness of the barrier is entirely independent of the character of the soil.

2. Bugs that are massed along the barrier are not swept over by sudden gusts of wind.

3. There is not the difficulty of oil glazing over, or of dust, clods, straws, etc. settling on it and forming bridges over which the migrating hordes could pass.

4. The amount of time and labor required to keep the barrier working effectively is considerably less than in the case of other barriers.

5. The total amount of chemical necessary for a barrier of a given length is proportionately much smaller than that necessary for a creosote-furrow barrier.

6. The paper barrier introduces the possibility of using more expensive chemicals which may have greater repellent values and more lasting qualities. In preliminary tests pine tar, pine oil, beta-naphthol, wood creosote, and refined creosote have shown considerable promise as materials which might economically be used in connection with this type of barrier. The development of chemically treated chinch bug papers which would not need re-treatment does not seem outside the realm of practicability and is already being investigated by several commercial firms.

ACARINA AS POSSIBLE VECTORS OF THE DUTCH ELM DISEASE

ARTHUR PAUL JACOT

Scolytus multistriatus is generally regarded as the vector of the Dutch Elm Disease fungus *Graphium ulmi* (more correctly *Ceratostomella ulmi*). There are certain irregularities in connection with Scolytus transmission which are not only puzzling but which lead to the suspicion that there is another related factor which has been overlooked. Furthermore some Graphium positive elms have been found which evidently had not been affected by Scolytus. The general result of these findings is to lead entomologists to seek for other vectors besides the imported beetle. In addition to various insect possibilities as cicadas, katydids, tree-hoppers, and certain beetles, one might suspect an extremely ubiquitious group, the mites.

Although ten species are common denizens of elm bark, four may be ruled out as predaceous. The Oribatoidea, of which there are at least five species, feed upon fungi, algae, lichens, and other vegetable tissues. They are the hosts of certain minute fungi. As "saprophytes" they are in continual contact with fungi, and to such an extent that their bodies usually carry fungus spores. I have gone into this phenomenon in some detail in an earlier paper.[1] On elm, oribatids are common under the bark scales, and enter beetle burrows and all openings, being extremely thigmotactic. I have repeatedly found them in the egg tunnels and larval galleries of Scolytus, Hylurgopinus, buprestids and cerambycids. The adults of one species may be found to the extent of five or six to twenty or twenty-five per square inch, depending upon the amount of available cover, and on unsprayed trees. Trees that have been regularly sprayed have very few acarina. These oribatids may be carried from tree to tree by being washed off by beating rains, to ascend the nearest tree. They are also carried by birds in nesting material. Thus their importance as vectors is not great.

This can not be said of the tyroglyphoid mite which is found on elms in much greater numbers than the Oribatoidea. These minute whitish mites may be found in all stages throughout the year from top to bottom of the tree, under the bark scales and in every available niche and cranny. They are often to be found in the frass of larval galleries, especially during the winter. These mites go through an accessory

[1]Jacot, A. P., 1930, Moss-Mites as Spore-Bearers, Mycologia, vol. 22, pp. 94–96, fig. 1.

stage of development called the wandering nymph. In this stage they develop a large, compound sucker by which they attach themselves to other arthropods for transport to a new tree or locality. I have found *Scolytus multistriatus* beetles with as many as thirty or more of these passengers. It may well be that these tyroglyphoid mites which are sometimes numerous in the coremia beds of *Ceratostomella ulmi* in Scolytus and Hylurgopinus egg tunnels, and which are carried about by these beetles, are the neglected factor in the transmission of the Dutch Elm Disease.

I have also found a minute, unidentified mite attached to Scolytus larvae in their galleries.

Finally the cerambycid beetle *Saperda tridentata* common in elms, is rather generally parasitized by a gamasoid mite, as it emerges from the elms as an adult. These mites are usually found three together on different parts of the body, though as many as six or seven may occur on one beetle. Their relation to *Ceratostomella ulmi* while going through their immature stages on the elm is unknown.

Scientific Notes

***Microbracon cushmani* Mues. attacking *Desmia funeralis* Hbn. in the San Joaquin Valley, California.** On October 7, 1932, the attention of the writers was called to a localized outbreak of the grape leaf folder, *Desmia funeralis* Hbn., which was doing severe damage in three vineyards near Sanger, Fresno County, Calif. In all, some 34 acres of grapes were heavily attacked, including 10 acres of Ribier, 12 of Alicante, and 12 of Cinsaut (Malvoise). The owner estimated the resulting loss of crop at 10 per cent for the Ribier, 20 per cent for the Alicante, and 60 per cent for the Cinsaut. The larvae were not only causing damage by rolling the leaves, but were also feeding on the clusters of ripe grapes and, by breaking the skin of the berries, were affording entrance for various decay fungi. On the above date, the current larval brood was well grown.

A species of *Microbracon* was found actively parasitizing the larvae in the rolled leaves. Sixteen specimens reared from paralyzed larvae were identified by C. F. W. Muesebeck of the Division of Identification and Classification of Insects, Bureau of Entomology, as *Microbracon cushmani* Mues. The occurrence of this species in the San Joaquin Valley attacking *Desmia funeralis* appears to be a new distribution and host record.

These vineyards were visited several times in the fall of 1933. Infestation by the grape leaf folder was of slight importance, materially less than in 1932. *Microbracon cushmani* was present in considerable numbers. The writers feel that the work of the parasite was effective in controlling this localized epidemic of the grape leaf folder.

HEBER C. DONOHOE and DWIGHT F. BARNES, *Dried Fruit Insect Laboratory, Bureau of Entomology, U. S. Department of Agriculture, Fresno, Calif.*

Hydrogenated Naphthalene Against Clothes Moths. In preliminary tests, made under a simulation of practical conditions, hydrogenated naphthalene (1, 2, 3, 4 tetra-hydro naphthalene) has shown considerable promise as a fumigant against the webbing clothes moth (*Tineola biselliella* Hummel). In situations where continuous fumigation is not practicable, this material has a distinct advantage over flake naphthalene, in that it is more volatile and more rapid in action. It is not anticipated that it will replace flake naphthalene, which has a distinct field of usefulness, but that it will meet a need for a quicker acting fumigant for household use against clothes moths. Hydrogenated naphthalene is a liquid which can be applied by spraying or by various other methods, such as absorption in fabrics or other porous materials. It is cheap and noninjurious to fabrics, and, under ordinary conditions, noninflammable and nonexplosive. Further tests are in progress.

WALLACE COLMAN, *Associate Entomologist, Bureau of Entomology, U. S. Department of Agriculture*

Stimulation of Fig Insects by Certain Fumigants. The tabulation below summarizes the results of 50 fumigations of figs carried on near Fresno during the 1933 harvest. The object of the work was to determine the relative merits of four common fumigants with respect to their stimulating effect on certain insects. Stimulation was judged by the percentage of insects that were caused to leave the fruit before death occurred.

The percentages were obtained by counting all insects that died on the floor of the fumigation boxes and estimating, by detailed examination of weighed samples, the number of insects killed inside the fruit. With a few unimportant exceptions all the fumigants were 100 per cent lethal at the dosages used.

Two series of fumigations, one of 38 tests and the other of 12, were made. The first series involved a total of 3,898 pounds of partially dried figs, which contained about 115,400 larvae (98.5 per cent *Carpophilus hemipterus* L.) and about 15,000 beetles, chiefly of the same species. Infestation in the other series, comprising 437 pounds of dried figs, included about 8,700 larvae of the raisin moth (*Ephestia figulilella* Greg.).

AVERAGE PERCENTAGE OF INSECTS CAUSED TO LEAVE FIGS AND KILLED BY FUMIGATION WITH:

	Chloropicrin	Ethylene dichloride-carbon tetrachloride mixture	Carbon disulphide	Calcium cyanide
Larvae (98.5 per cent *Carpophilus hemipterus* L.)	67.8	60.6	10.1	1.0
Beetles (chiefly *C. hemipterus*)	72.3	70.0	46.8	42.6
Larvae (*Ephestia figulilella* Greg.)	2.6	0.5	0.2	0.0

DWIGHT F. BARNES and CHARLES K. FISHER, *Dried Fruit Insect Laboratory, Bureau of Entomology, U. S. Department of Agriculture, Fresno, Calif.*

Notes on a Fungus Attacking Onion Thrips. During the summer of 1932 the writers, in connection with field studies on the biology and control of onion thrips in the Connecticut Valley, discovered large numbers of thrips adhering to the leaves of the onion plants. Subsequent examination revealed the presence of a fungus in these

dead and dying thrips. In the field the first evidence of attack was a slowing up in activity and general sluggishness on the part of the infected thrips. Microscopic examination in the laboratory showed the bodies of these thrips to be completely filled with the mycelium of the fungus, which later broke up to form chlamydospores.

Specimens of infected thrips were submitted to different authorities for identification. Professor H. M. Fitzpatrick and Mr. Thompson at Cornell University determined the fungus as a species of *Empusa*, probably *sphaerosperma*.

During the remainder of the season it was found that the fungus was well distributed thruoughout the onion growing section of the Connecticut River Valley in Massachusetts. Studies on the thrips abundance for the season revealed that from approximately the middle of August the decline of numbers of thrips, instead of following the usual curve established by life history studies over a period of years, dropped off very rapidly. Since there was no other apparent reason for this rapid decline, it is believed that the presence of the fungus had much to do with this. It was noted in many fields that the appearance and increase in abundance of this fungus were coincident with the sharp decline in thrips abundance.

During the season of 1933 the fungus was observed to be present over approximately the same area but was not as abundant, and did not cause such a reduction in the numbers of thrips as was noted during the previous season, undoubtedly due to adverse weather conditions that prevailed during midsummer.

A. I. Bourne and F. R. Shaw

The Secretion of the Colleterial Glands in the Parastic Chalcids. When the colleterial glands are removed from certain species of parasitic chalcids and then observed by transmitted light, the contents exhibit the opaque whiteness of a waxy substance such as paraffin. When the material is stained with aceto-carmine, the contrast between the appearance of this substance and that of the body tissue is very distinct.

Apparently it is the secretion of these glands which is used to form the suction tubes so common with many species of Hymenoptera for feeding on the body fluids of hosts located in protected situations. *Dibrachoides* thus feeds on the cocooned prepupa of the alfalfa weevil and *Peridesmia* on the weevil eggs located within the stems of the alfalfa. Although the feeding tube is delicate and brittle it is strong enough to permit the entire contents of an egg to be sucked out. The writer has observed the slow collapse of the host egg as its contents were thus extracted.

One of the first observations concerning this material was that of Girault & Sanders (Psyche, 1910) who noted "a white mycelium-like growth" at the oviposition puncture made by *Mormoniella*. Later Froggatt in 1919 observed "a tiny white body" after this parasite had sucked up a drop of liquid which appeared after the withdrawal of the ovipositor.

During oviposition the eggs of these *Hymenoptera* apparently become coated with this secretion. It probably serves to fasten the eggs of parasites to their hosts. Also it may serve to protect the eggs of endoparasitic forms from the phagocytic blood cells of the host. Previous investigators have noted that phagocytes do not adhere to a greasy or waxy surface. As soon as this surface is removed phagocytes may make contact. When they do so they are unable to free themselves again. Objects too large for a single phagocyte to ingest accumulate many phagocytes and thus become encapsulated. The lethal effect of this encystment is probably due simply to the cutting off of food and oxygen supply from the embryo.

It is possible that the presence of such a waxy coating on the egg would delay the incapsulation process until hatching occurred.

Variations in the quantity and quality of this protective coating and in the ability of the hosts to remove it may account, in part, for the specificity of certain endoparasites.

A review of the literature indicates that cellular or phagocytic immunity does not occur in the Aphididae or higher Hymenoptera. The number of blood cells in these groups is reported as relatively low. This appears to be correlated with the absence of cell coagulation.

STANLEY E. FLANDERS, *Citrus Experiment Station, Riverside, California*

Fish Meal as a Food for Clothes Moths—Supplementary Note. Last year I published a brief paper (Jour. Econ. Ent. 26:720–722. 1933) describing a method for breeding clothes moths on fish meal. The number of letters which have been received since the article appeared, indicate that a great many persons are interested in rearing these insects. It therefore seems worth while to publish an additional note explaining certain improvements in the method which have been made during the past year.

In the summer of 1933 some of our containers became infested with predacious mites. Although the point was never proved, mites were probably carried from old containers to new ones on the bodies of adult moths. It therefore appeared advisable to start new colonies with eggs instead of with adults. To get a supply of eggs, moths are placed in a glass jar with pieces of flannel. Each day fresh flannel is put in the jar and the pieces on which eggs have been laid are removed. If the flannel is cut into squares, about 3 x 3 inches, the pieces are easy to examine under a binocular, and any mites present can be removed. The gallon cardboard containers are prepared as explained in the original article. After examination under a binocular, the pieces of flannel, on which eggs have been laid, are placed on the layer of fish meal in the bottom of the container. Each piece of flannel is sprinkled lightly with some of the fish meal before another piece is added. Since this method of starting new colonies was adopted, no further trouble with mites has been experienced.

It has been found also that larvae are more easily removed from small containers than from large ones. The half-pint size, commonly used at stores for cottage cheese and ice cream, is just about right for this purpose. Several pieces of flannel, on which eggs have been laid, are placed in one of these small containers, each piece of flannel being sprinkled lightly with fish meal. The larvae get enough to eat but cannot bury themselves in a thick layer of meal such as is put in the large containers. By using a number of these small containers, one can keep on hand a supply of larvae of any age desired. Although the method was developed for breeding the webbing clothes moth (*Tineola bisselliella*), the case-making species (*Tinea pellionella*) can be reared satisfactorily in a similar manner.

Adults are difficult to catch in the small containers, since they have no place in which to hide and can so easily escape. For rearing adults it is advisable to use the gallon size and black cloth as described in my original article. Hence at Ithaca both the large and small containers are in constant use.

Several people have written to ask what fish meal is and where it can be obtained. The meal which we have found so satisfactory is "white fish meal" and is manufactured by the Dehydrating Process Company, Boston, Massachusetts.

GRACE H. GRISWOLD, *Cornell University*

Solvents for Cryolite. Cooperative tests by the Bureau of Chemistry and Soils and the Bureau of Plant Industry in 1933 (Wash. State Hort. Assoc. Proc. 29th Ann. Meeting, pp. 86–96) showed that apples sprayed with cryolite and fish oil or mineral oil were difficult to clean to the Department of Agriculture's tolerance of 0.01 grain fluorine per pound. This was especially true where these materials had been used for six cover sprays and some washing treatments were not effective on apples which had received cryolite and oil only in the last two cover sprays.

In practically all the washing tests the brush machine treatments were more effective than flotation or dip machine treatments, showing that removal was mostly by physical rather than chemical action. Therefore in an effort to find better solvents for the removal of cryolite residues, a study of the solubility of cryolite has been undertaken. Preliminary findings are as follows:

1. The solubility of cryolite in dilute hydrochloric acid (1.5 gm. HCl per 100 cc.) at 20° C. was found to be 0.2404 g. F per 100 cc. but when 2.0 gram of sodium chloride was added to 100 cc. of the dilute acid the amount of fluorine going into solution was reduced to approximately half that amount. It is common practice to use acid plus salt for the removal of lead arsenate spray residues from apples, but this mixture is evidently not the best solvent for cryolite residues.

2. Sodium chloride, sodium bicarbonate and monosodium phosphate each decreased the solubility of cryolite in water at 20° C. For instance, the solubility of cryolite in water was found to be 0.0220 g. F per 100 cc., but this was reduced to 0.0039 g. F per 100 cc. in a solution of 0.125 gram of sodium bicarbonate per 100 cc. This discovery may find some useful application in orchard spraying. For example, the addition of small amounts of such materials to cryolite will render it less soluble and prevent loss by "run off" of the solution and perhaps minimize the danger of foliage injury by providing an optimum pH value.

3. On the other hand, several compounds when added to 1.5 per cent hydrochloric acid or to water increased the solubility of cryolite. For illustration the solubility of cryolite in 1.5 per cent hydrochloric acid was increased from 0.2404 g. F per 100 cc. to 0.5576 g. F per 100 cc. when the dilute hydrochloric acid solution contained 1 gram of boric acid (H_3BO_3) per 100 cc. Other compounds that increased the solubility were aluminum salts and ferric salts.

Present indications are that suitable practical solvents for cryolite and other water-insoluble fluorine compounds will be found. The effects of these solvents on apples as well as their effects on lead arsenate removal when mixed spray schedules have been used must be determined before they can be recommended for spray residue removal. However, there is no reason to believe they will be deleterious to fruit or less effective in removing lead arsenate than solvents now used for this purpose.

R. H. CARTER, *Associate Chemist, Insecticide Division, Bureau of Chemistry and Soils, Washington, D. C.*

Progress Report Regarding the Introduction in Oregon of *Digonichaeta setipennis* Fall., a Tachinid Parasite of the European Earwig.[1] This paper deals with the progress made during 1931, 1932, and 1933, at the Portland Parasite Laboratory, in

[1]Published as Technical Paper No. 193 with the approval of the Director of the Oregon Agricultural Experiment Station. A contribution from the Department of Entomology.

rearing and liberating in Oregon of *Digonichaeta setipennis* Fall., the most important entomophagous parasite of the European earwig. A review of the work concerning the introductions of the tachinid parasites of the European earwig into Oregon from the inception of the project in 1923 to the fall of 1930 was reported in this Journal.[2]

Although *Digonichaeta* was known to have been well established within certain areas in the city limits of Portland by 1929 and 1930, it was thought advisable to increase its numbers under laboratory conditions so as to reenforce previous liberation areas; to establish new liberation areas in Portland and Multnomah county and to maintain a supply of parasites that could be liberated in other localities in Oregon. Since most of the funds used in rearing and liberating this parasite were furnished by the City of Portland and Multnomah county, practically all liberations up to and including 1931 were made in those localities. From other districts in Oregon during the past few years many requests for parasites were received. In 1923 the European earwig was known in 14 localities in Oregon, with Portland having the major infestation, but by 1931 the earwig was known from most of the urban areas of Western Oregon and from several places in Eastern Oregon. There were frequent reports in 1932 and 1933 of the obnoxious pest in agricultural and forest regions in Western Oregon.

During 1931 there were 27,151 adult parasites reared at the laboratory. From this number 5,067 mated females and 20,800 parasitized earwigs were liberated in various areas in Portland and Multnomah county and a large laboratory stock of the parasite was produced for use in 1932.

In 1932 no actual count of adult parasites could be made by the small part-time force working at the laboratory, but a conservative estimate based on partial counts throughout the active season placed the number of adults considerably in excess of 50,000. About 1200 puparia of the parasite were shipped to Dr. David Miller for colonization purposes in New Zealand in March, 1932. Dr. Miller informed us that 1,071 adults emerged from these puparia at Cawthorn Institute, located at Nelson, New Zealand. From May to September, 1932, approximately 34,350 adult parasites were liberated in Portland and Multnomah county.

Cooperative arrangements with the Extension Division of the Oregon State Agricultural College and the Oregon State Experiment Station were made in the early part of 1932 to supply localities in Oregon outside of Multnomah county with parasites. A production cost charge of one cent per parasitized earwig was made to these communities. Various individuals and civic organizations in 18 towns and cities located in 9 different Oregon counties purchased 61,250 parasitized earwigs through their agricultural agents.

The earwigs sent to these communities were parasitized by placing the parasitic larvae on the hosts which were anaesthetized by ether. This process was described in this Journal[3] recommending chloroform as the anaesthetic, but subsequent investigations disclosed that ether was a much better anaesthetic for this purpose. After the earwigs were parasitized, they were placed in shipping cans and expressed to county agricultural agents for liberation in earwig infested areas.

[2]Mote, D. C. The Introduction of Tachinid Parasites of the European Earwig in Oregon. Journ. Econ. Entom., Vol. 24, pp. 948–956.

[3]Dimick, R. E. Hand-parasitizing the European earwig with the larvae of *Digonichaeta setipennis* Fall. Jour. Econ. Entom. Vol. 24, pp. 962–964.

In 1933, approximately 25,000 adult parasites were reared at the laboratory, the majority of which were liberated in Portland and Multnomah county. In addition, 21,500 parasitized earwigs were liberated in twelve communities in Oregon located outside of Multnomah county and 3000 were released to locations in Washington.

The European earwig in Portland during the 1932 season became greatly reduced in numbers in comparison with former years, except in one small area where it was quite abundant. By 1933, this reduction was general throughout the city and quite marked in many places in Multnomah county. This decrease was attributed to parasites by many of the citizens. Whether this noticeable decrease was the result of parasites which were known to be plentiful in the field or whether it was the result of other natural factors was not ascertained. Climatic conditions could hardly account for the marked reduction in earwigs in Portland, for in many Western Oregon communities, some of which were located near Portland, in which no parasites had been liberated, the earwig appeared to be increasing in numbers. However, until an investigational survey can be made in Portland and other Oregon communities in which the parasite has been liberated and established, to ascertain the amount of control *Digonichaeta* exerts on the European earwig, such a hypothesis is as yet merely supposition.

R. E. DIMICK, *Assistant Entomologist* and DON C. MOTE,
Entomologist, Oregon State College

Scouting for Elm Scolytids. On September 16, 1933, a survey was started to ascertain, if possible, the presence and distribution of *Scolytus scolytus* Fab. and *Scolytus multistriatus* Marsh. in the Eastern States. The work was under the direction of Dr. F. C. Craighead, in charge of the Division of Forest Insects, Bureau of Entomology, U. S. Department of Agriculture. The survey was made because these two species of beetles are known to carry the Dutch elm disease (*Graphium ulmi*) in Europe. Both the Dutch elm disease and *Scolytus multistriatus* Marsh. occur in the United States.

The scouting work did not reveal the presence of *Scolytus scolytus* Fab. in any of the areas visited. Either it has not established itself or it has not become sufficiently abundant to be found with the usual scouting methods.

Parts of the States of Massachusetts, Connecticut, Rhode Island, New York, New Jersey, Maryland, Delaware, and Virginia were scouted, with special emphasis on the ports of Boston, New York, Philadelphia, Baltimore, and Norfolk. In addition to these areas, the cities of Cleveland and Cincinnati, Ohio, Indianapolis, Ind., Louisville, Ky., Kansas City, Mo., Knoxville, Tenn., and New Orleans, La., were visited. Most of these places contain veneer factories where imported elm logs have been utilized.

Scolytus multistriatus Marsh. was first found in this country in 1909, by Chapman, at Cambridge, Mass. More complete records obtained by the survey indicate that the insect may have been introduced at three different ports—namely, Boston, New York, and Philadelphia—as evidenced by its greater abundance near these cities.

The infestation in Massachusetts extends as far north as Haverhill, near the New Hampshire line, south to Halifax, and west to Wayland. A survey of southern New Hampshire and Maine might have shown that it extends even farther north along the Atlantic coast.

The infestation centering in New York City extends into Connecticut as far east and north as Meriden and New Milford, and in New York extends north along the

Hudson River Valley to Clermont, Columbia County. It was found as far west as Bloomingburg, N. Y., although the mountainous section west of the Hudson River probably acts as a partial barrier at least. On Long Island the beetle was found as far east as Bay Shore in the southern part and Rosslyn in the northern section.

Fig. 91.—Distribution of *Scolytus multistriatus* Marsh. in the United States, based on information available to the Bureau of Entomology, March 1, 1934.

The entire State of New Jersey, with the exception of the southern part, can be included in the infested area. The bottom-land type of southern New Jersey is widely separated from that in the north by a broad band of the oak-pine type and does not as yet show infestation. The New Jersey infestation might be credited to both New York and Philadelphia, for there is a greater scarcity of the beetle in the intervening area at a distance from each center.

The Philadelphia infestation extends as far north as Bangor, Pa., and west to the Susquehanna River. The mountains which run diagonally through the State probably act as more or less of a barrier to the beetle, owing to the absence of elm in the highlands.

The survey showed also that our native elm bark beetle, *Hylurgopinus rufipes* Eichh., has a wide range of distribution. Records were taken in the States of Massachusetts, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, Ohio, Indiana, Kentucky, Missouri, and Kansas. This insect seems to be a northern species, as indicated by its greater abundance in the northern sections visited. It is quite possible that some of the records of *Scolytus multistriatus* Marsh. in the literature should be credited to this beetle instead, as the report was based, not on beetle specimens, but on the engravings, and the identity of these might easily be confused. It is also possible that *Hylurgopinus rufipes* Eichh., as well as several of our other native elm insects, may act as a vector of the Dutch elm disease. Very little is known of the habits of this species, so the likelihood of its acting as a vestor cannot be measured.

J. N. KNULL, *Ohio State University*

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A. A. A. S Winter meetings, 1934-1935, Pittsburg: December 1935, St. Louis; Summer meetings, 1934, Berkeley, June 18–23; 1935, Minneapolis.

The Dutch elm disease situation, an entomological as well as a pathological problem, brings to the front a question of great practical importance. The developments of the last few weeks have shown a great increase in the number of diseased trees and an appreciable spread into more territory, indicating that available funds, Federal, State and local, are inadequate or likely to prove insufficient within a few weeks. Present conditions make it very difficult to secure additional appropriations. A question naturally arises as to the policy which will be adopted in regard to the Dutch elm disease and its presumably important carrier, the European elm bark beetle. Severe limitations in financial resources can cripple the work and are more than likely to make impossible effective control or eradication of this disease. The situation is made more difficult by the ultra conservatives, who would do nothing until success can be guaranteed, and this latter is impossible. Conversely, if limited funds make it impossible to deal adequately with the situation, there will soon come a time when the distribution of the disease and the abundance of the beetles make it impossible to secure the necessary funds. Conditions similar to these arose in the early days of the gipsy moth work and resulted in an abandonment of the work at a time when eradication was in sight. It is possible that an early appreciation of the Japanese beetle and its potentialities would have brought about actual extermination of the insect before it had become too widely distributed.

This might have been the story of the European corn borer if the ten million dollars used for a general clean-up had been available years before for eradication. It follows that large scale control or eradication work on insects or diseases must not only have the benefit of far-sighted direction, but must be supported by ample funds, otherwise the records of the future, like many of those in the past, will list failure after failure, tempered though these may be by a gradually disappearing optimism. America has been a leader in efforts of this nature, and much of value has been accomplished. The opinions of experienced entomologists, entomological engineers if one prefers, must in the future be given greater weight not only in direction, but in the marshalling of resources if the needs of the day are to be met.

Current Notes

Professor T. D. A. Cockerell of the University of Colorado, having reached the age limit, has retired and has been appointed Professor Emeritus, according to a recent note in *Science*.

Dr. P. A. Readio has terminated his appointment at the University of Kansas to accept an assistant professorship at Cornell University. He is in charge of the New York State research work in entomology on the Dutch elm disease, made possible by a special appropriation. His headquarters are at the Boyce Thompson Institute for Plant Research, Yonkers, N. Y.

The National Shade Tree Conference will hold its annual meeting August 30 and 31 at the Carnegie Institute, Pittsburgh, Pa. Nationally known authorities will present papers in their respective fields and practical as well as scientific problems will be discussed. The entire Dutch elm disease situation, something of great importance to commercial tree men, city foresters and shade tree commissions throughout the country, will occupy a prominent place on the program. There will be educational exhibits of insects and diseases affecting trees and of materials and equipment used in practical tree work.

Horticultural Inspection Notes

The terminal inspection of parcel post shipments of nursery stock was discontinued in Arkansas on March 30, 1934.

E. R. Sasscer visited certain ports of entry in the States of Texas, California, Oregon, and Washington, during the month of May.

Howard E. Guthrie and Orville L. Williams will assist Henry Ness in inspection work in Iowa this summer.

Edward Johnson has been appointed assistant horticulturist of Maine to take the place of Danial Clement who passed away several months ago.

Due to a reduction in the appropriations for the fiscal year 1935, it has been necessary to discontinue the services of 4 inspectors at the port of New York; 2 at Nogales, Ariz.; 1 at Ysleta, Tex., and 2 at Washington, D. C.

About eight thousand Japanese beetle traps are being operated in Maryland this season, according to E. N. Cory, State Entomologist. Of these, two thousand are are being used as a suppressive measure in the city of Baltimore.

The following transfers of inspectors of the Division of Foreign Plant Quarantines have been made: M. S. Mirimanian from Brownsville, Tex., to New Orleans, La.; L. A. Roberts from Houston, Tex., to New Orleans, La.; A. K. Pettit from New Orleans, La., to Brownsville, Tex., and O. D. Morris from New Orleans, La., to Houston, Tex.

W. A. Price, State Entomologist of Kentucky, reports the issuance of a new regulation designating Menifee, Morgan, Powell, and Wolfe counties in that State as white-pine growing districts and authorizing agents of the Commissioner of Agriculture to remove wild currant and gooseberry plants in those counties when such bushes are found "growing within 1500 feet of valuable pine forests." The order also covers the destruction of cultivated bushes "located at abandoned or unoccupied houses."

S. B. Fracker accompanied by J. M. Corliss of the Bureau of Plant Quarantine spent most of the month of June visiting the premises of white pine-growing nurseries in the Middle West to survey the progress which has been made in Ribes eradication around nurseries. The Federal Forest Service has established a number of nurseries in Minnesota, Wisconsin, and Michigan, with a capacity of large numbers of forest trees, and expects to be growing from fifteen to twenty million white pines in these nurseries for reforestation purposes.

"Colorado potato beetle eggs have been taken from tomato plants shipped into California and are occasionally to be found in eggplant plants" according to the California State Department of Agriculture, and the State quarantine pertaining to the beetle has, therefore, been revised to place an embargo on plants of the tomato and eggplant, as well as potato tops. The quarantine applies to all parts of the United States except Nevada and the Territory of Hawaii, this State and Territory having been released under the recent revision. A slight change has also been made in the requirements as to screening and certification of potatoes.

Under the agricultural appropriation act for the fiscal year 1935, the Federal bureau of entomology and the bureau of plant quarantine were combined into one bureau, effective July 1, 1934. The new bureau, to be known as the Bureau of Entomology and Plant Quarantine, will take over all research on entomological problems, the enforcement of all regulatory work relating to insect pests, and those phases of the work of the Bureau of Plant Industry which involve the field eradication and control of plant diseases. L. A. Strong is Chief of the new bureau, and S. A. Rohwer and A. S. Hoyt will be Assistant Chiefs. The research work is organized in 11 divisions, and the regulatory work in 8 divisions. The various sections of the new bureau which were scattered in several buildings in Washington, moved in July to the "South Building" at 14th St. and Independence Ave., south of the main Agricultural Building on the Mall. The bureau is occupying parts of the fourth, fifth, and sixth floors on the C Street side of the building.

Regulations concerning the white-pine blister rust were recently placed by the States of Virginia and West Virginia. The Virginia quarantine prohibits the growing of currants and gooseberries in an area of 54 counties, and provides authority for the destruction of Ribes on any premises in the State except that the destruction of cultivated species is limited to those growing within 1,500 feet from white-pine stands. In West Virginia, the Forest Service Nursery at Parsons was brought under protection by amending State quarantine order No. 5 to provide for the establishment of surrounding quarantine zones in which *Ribes nigrum* and other species of currant and gooseberry plants may not be grown or possessed.

Addenda et Errata

Since the publication in the December 1933 issue of an obituary notice of the late Dr. S. I. Kuwana, widely and favorably known in this country, Professor E. O. Essig has been advised that he was awarded the degree of Doctor of Agriculture by the Imperial Japanese Government in 1925.

Page 719, line 26 in the June 1934 issue for 1928 read 1898.